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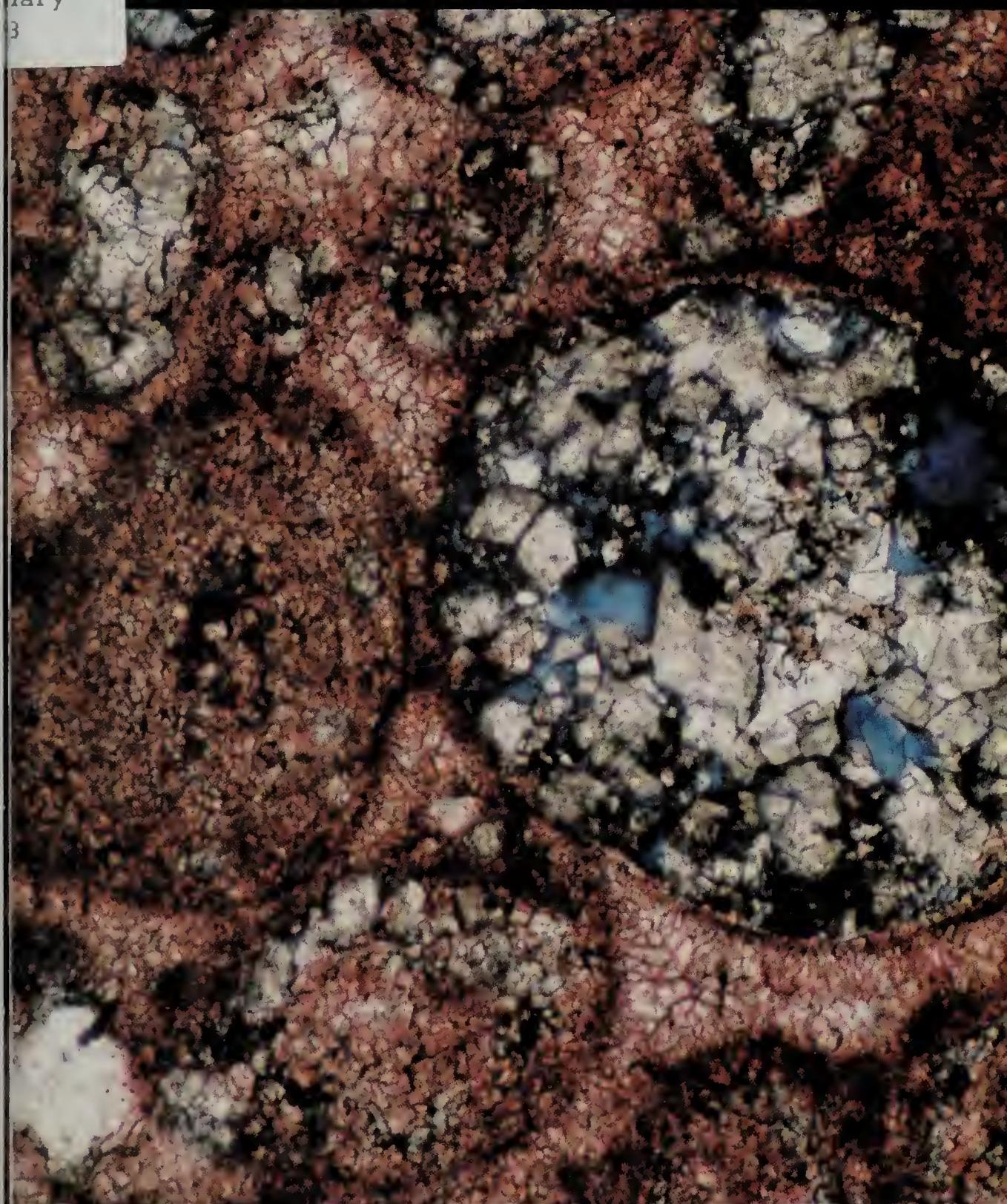
NATURAL HISTORY

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COVER PHOTOGRAPH: Ooids (concentrically layered calcium-carbonate spheroids) in the Jurassic Smackover Formation. The ooids have responded very differently to the physicochemical influences that have impinged upon this rock over the past 150 million years. To the right of center is a large ooid that has been partially replaced by dolomite crystals (off-white rhombs) and contains much secondary porosity (dark blue). To the left of center is a slightly smaller ooid which has hardly been changed at all. (The slide has been stained with Alizarin Red-S, which stains calcium-carbonate bright red.) The two ooids are connected where they are closest to each other by a vertically oriented strip of finely crystalline calcium carbonate in the very center of the photomicrograph. This is meniscus cement, which formed in a meniscate water droplet shortly after this sediment was deposited. Meniscus cement cannot form when the pores are saturated with water, so this tiny patch of calcium-carbonate "glue" proves that this rock was exposed to the air for a short time before it began its long downward journey. When the sample was collected, it had reached a dept of nearly 2 1/2 miles below the surface. The visual study of carbonate rock pore systems is reviewed in "Visual pore-system analysis," by David C. Kopaska-Merkel.

David C. Kopaska-Merkel is a geologist at the Geological Survey of Alabama, where he studies carbonate rocks and the holes in them. The cover photograph was taken during the course of an ongoing study of reservoir characteristics of the Smackover Formation, the most prolific oil-producing unit in Alabama.

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VISUAL PORE-SYSTEM ANALYSIS¹

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ABSTRACT

Pore systems consist of coarser elements (pores) connected by finer elements (pore throats). Indirect methods of pore-system analysis measure pore throats better than pores, whereas visual methods capture the characteristics of pores better than those of pore throats. The geometry and topology of pore systems strongly affect fluid-flow characteristics, and pore systems classified by pore type differ systematically in fluid-flow characteristics. Hence, visual pore-system analysis is an important component of the study of fluid-flow through porous media.

A genetic pore-system classification that is congruent with geometrical differences among pore systems is most useful because predictivity is highest when classifications have a genetic basis and because groups differ in fluid-flow characteristics. Ternary pore plots, which are ternary diagrams whose apices are pore types, are simple tools that effectively summarize pore-system geometry.

INTRODUCTION

The fields of petroleum geology, hydrology, and environmental science share a common concern with interstices in rocks. The fluids of interest in these disciplines (petroleum, fresh water, and waste material) travel in the subsurface through networks of (commonly) microscopic openings. In the subsurface, multiple fluid phases move by laminar flow through three-dimensional networks of great complexity. Deterministic analysis of their geometry is essentially impossible; only the very simplest fluid-flow systems have proven amenable to deterministic analysis. Instead, one measures or calculates bulk properties such as porosity, permeability, transmissivity, tortuosity, and connectivity. These parameters are measured *in situ* using geophysical logs in well bores (Schlumberger, 1972), or in the laboratory on samples cut from cores (Kopaska-Merkel, 1991). Highly simplified models are studied experimentally (Wardlaw and McKellar, 1981).

Pore systems also can be studied visually, either by automated image analysis or qualitatively by eye. This sort of study can be conducted at several scales, from the 100+ micrometer range appropriate to a binocular microscope to the

¹Manuscript received 30 September 1992; accepted 21 January 1993.

submicrometer range of the scanning-electron microscope or electron microprobe. Even at high magnifications one aspect of pore-system geometry, pore-throat morphology, is difficult to observe. Pore systems are generally described as consisting of larger openings (pores) connected by smaller openings (pore throats). Conceptually this division is sound, because in any passage lacking side branches there must be a narrowest point, which exerts control over the rate at which fluids can flow through the passage. This narrowest point is the pore throat. In practice the concept works well too, because most pore systems do consist of large elements connected by smaller openings (fig. 1, A).

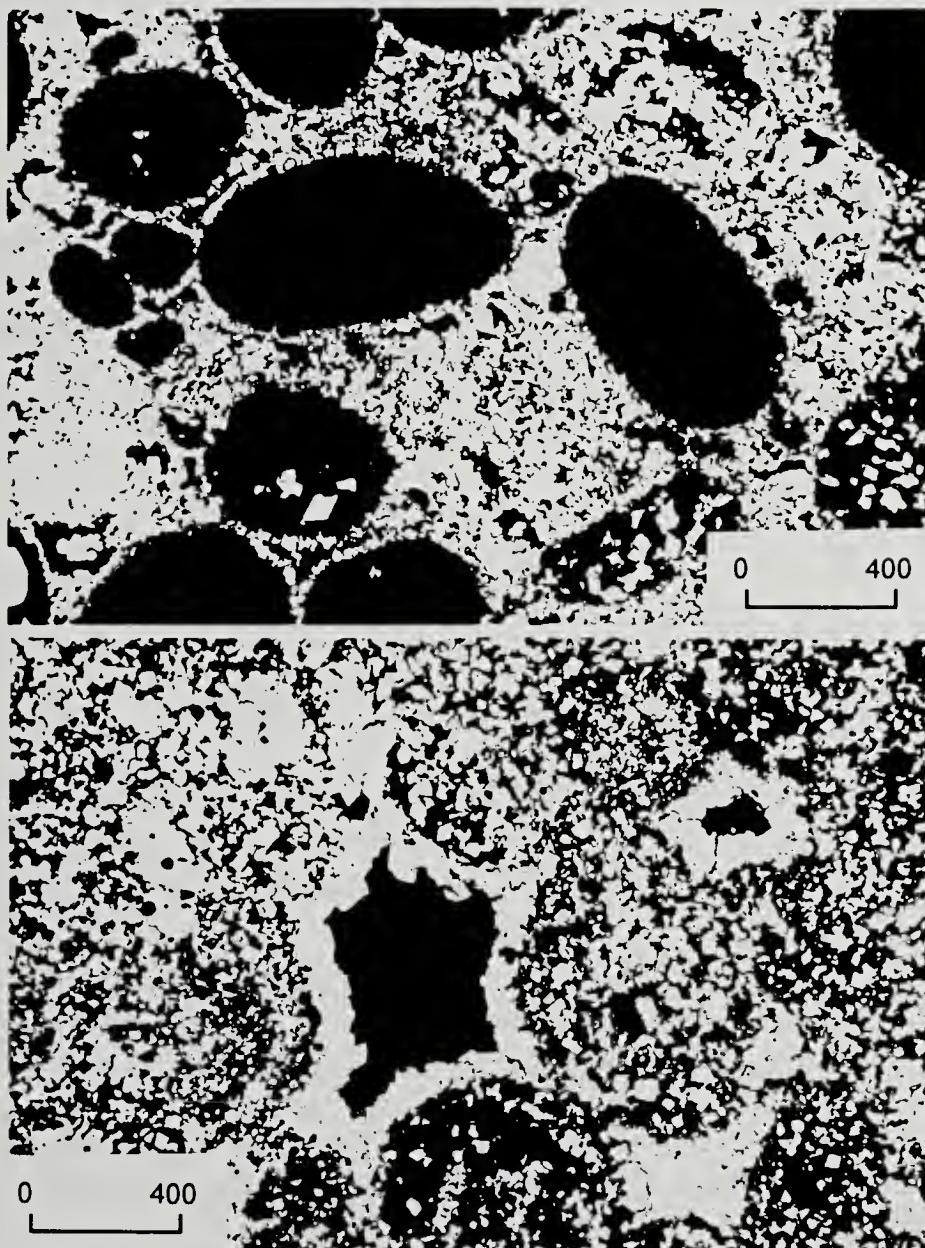


Figure 1. Thin-section photomicrographs of pore systems. Dark areas are pores; scales in μm . A) Sample of moldic pore system with large pores and much smaller throats. B) Example of secondary intraparticle pore system. (Large pore in center is remnant interparticle pore.)

Visual Pore-System Analysis

It is nearly impossible to acquire an appreciation for the number, distribution, size, or shapes of pore throats visually, even at high magnifications, whereas pores are obvious. By contrast, nonvisual methods of pore-system analysis detect pore throats readily, but have a great deal of trouble with pores. The most-common approach is porosimetry, wherein a nonwetting fluid (such as mercury) is injected under controlled pressure into a small sample. The pressure (capillary pressure) required to force fluid into a portion of the pore system is proportional to the size of the opening (Wardlaw, 1976; Kopaska-Merkel, 1991) and therefore a series of paired pressure-volume measurements corresponds to the sizes of pore throats and the total volume of pore space accessible through pore throats of those sizes (fig. 2). Thus, visual and nonvisual methods of studying pore systems are complementary.

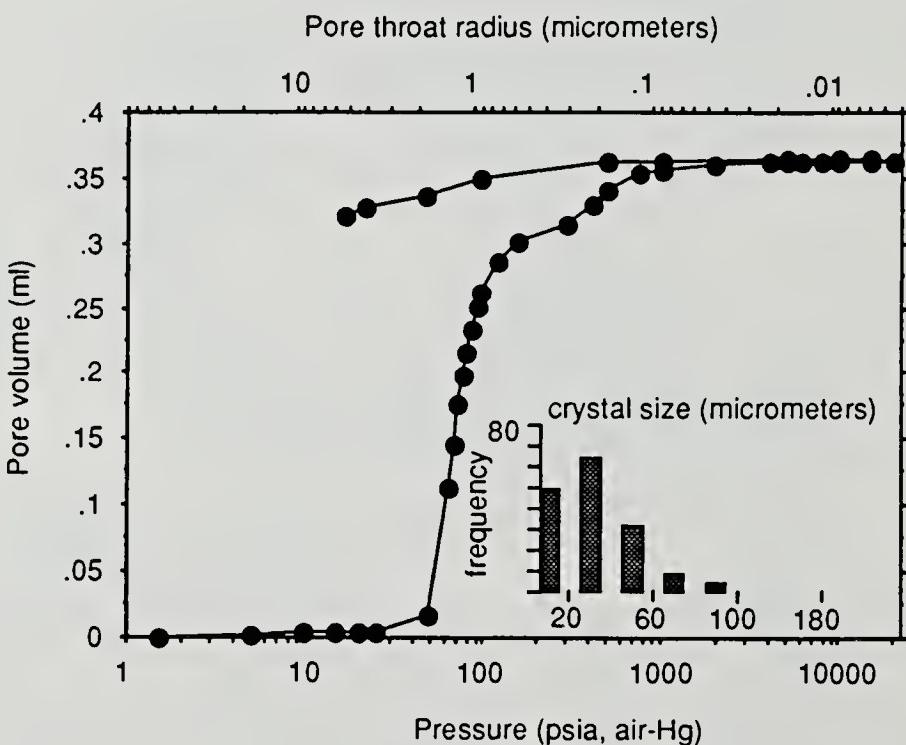


Figure 2. Capillary-pressure curve from sample of hydrocarbon reservoir rock, Smackover Formation, Alabama, with accompanying histogram of crystal-size distribution.

In this paper I outline a geometrical approach to visual pore-system analysis. Examples come from the Upper Jurassic Smackover Formation, a carbonate rock unit about 150 million years old that is an important reservoir for oil and gas from the Florida panhandle to Texas. In Alabama, the Smackover has produced more oil than any other rock unit. In the Smackover Formation, as in most rock units, the shapes and sizes of pores are closely related to their origins (Choquette and Pray, 1970). The Smackover strata described herein are carbonate sedimentary rocks, but many of the principles are far more widely applicable. Pore geometry in siliciclastic

sandstone is also commonly closely related to pore genesis (e.g., interparticle or particle-moldic pores) and even in igneous and metamorphic rocks, the physical characteristics of pores are controlled by their origins (e.g., vesicles in scoria). Hence, a geometrical classification has genetic implications and vice versa. This conformance of pore-system genesis and pore geometry in natural rock systems affects petroleum geology, hydrology, and environmental science. To the extent that other kinds of materials exhibit the same relationship between form and origin, the geometrical approach will be applicable in other disciplines.

CARBONATE ROCK CLASSIFICATION

Most Smackover reservoirs originated as nearshore-marine carbonate sediments with minor admixtures of noncarbonate material. Some of these reservoirs preserve abundant evidence of their environment of deposition. Others have been highly altered and their origins are unclear. The first group are conveniently classified using the scheme of Dunham (1962), whereas the latter ("crystalline dolostone" to Dunham) can be characterized in more detail following Sibley and Gregg (1987). The Dunham classification is simple to apply and the categories are directly related to depositional settings (fig. 3).

Depositional texture recognizable						Depositional texture not recognizable		
Original components not bound together during deposition						Crystalline carbonate (Subdivide according to classifications designed to bear on physical texture or diagenesis.)		
Contains mud (particles of clay and fine silt size)			Lacks mud and is grain-supported	Original components were bound together during deposition . . . as shown by intergrown skeletal matter, lamination contrary to gravity, or sediment-floored cavities that are roofed over by organic or questionably organic matter and are too large to be interstices.				
Mud-supported	Grain-supported	Packstone		Boundstone				
Less than 10 percent grains		More than 10 percent grains						
Mudstone		Wackestone						

Figure 3. Dunham classification of carbonate rocks (Dunham, 1962, table 1, p. 117).

Dunham recognized two first-order classes of limestone: those in which the original particles were bound together (boundstone) and those in which they were not. Limestone that is not boundstone is the most common; this group was divided by Dunham into particle-supported and matrix-supported rocks. Particle-supported rocks are grainstone if there is no fine matrix, and packstone if a fine matrix is present. Matrix-supported rocks are wackestone if particles constitute more than 10% of the rock; otherwise they are mudstone. One refinement to the Dunham

Visual Pore-System Analysis

classification is employed here: dolostone, rock made of dolomite, is classified in the same way as limestone if the primary rock fabric is recognizable, but with the prefix *dolo-*. For a recent review of basic carbonate sedimentology, see Friedman and others (1992).

THE SIBLEY AND GREGG CLASSIFICATION

Crystalline dolostone has for the past quarter century been classified descriptively according to the scheme of Friedman (1965). A recent proposal to classify dolostone in a different descriptive way (Sibley and Gregg, 1987) is used here. The Sibley and Gregg classification is based on crystal form and rock fabric, but in addition it takes into account the factor of crystal size. In this classification scheme, fabrics fall into two groups: (1) unimodal and (2) polymodal. Dolostone is further subdivided using crystal boundaries (planar versus nonplanar). Planar fabrics are yet further divided into those composed of dominantly euhedral crystals (having well-developed crystal faces) and those dominated by subhedral crystals (having poorly developed crystal facies). Thus six classes are defined: planar-e, planar-s, and nonplanar fabrics, for both unimodal- and polymodal crystal sizes. This classification focuses attention on the distinction between planar- and nonplanar crystal boundaries, which is thought to be a result of temperatures and saturation states during crystal growth. It also encourages the petrographer to take note of polymodality of crystal-size distributions, which probably result from multiple crystal-nucleation events.

CARBONATE PORE-SYSTEM CLASSIFICATION

CLASSIFICATION OF CHOQUETTE AND PRAY

The study of pore systems is fraught with difficulties, not least of which is the often bewildering array of shapes and sizes of pores. Before one can study pore systems, one must be able to classify pores. The most suitable classification for this purpose is genetic (Choquette and Pray, 1970) (fig. 4; also see their fig. 2). Choquette and Pray's classification is used throughout this report except where explicitly stated otherwise.

A genetic pore classification is used for two reasons. Genetically different pore types tend to differ in shape, size, distribution, and connectivity, which means that a genetic classification captures those aspects of pore systems that control fluid flow. Also, genetic pore types are directly related to primary sediment fabrics and to diagenetic processes (such as particle dissolution). This connection between pore types, deposition, and diagenesis maximizes the ability to predict pore-system distribution by relating it to geologic models of the depositional setting and of diagenetic processes.

Choquette and Pray (1970) regarded the time and place of porosity formation or modification as important factors that should be used in developing a genetic

Classification of Choquette and Pray	
Fabric Selective	Nonselective
Interparticle	Vuggy
Moldic	Channel
Secondary intraparticle	Fracture
Intercrystalline	Cavern
Fenestral	
Shelter	
Growth-framework	
Fabric Selective or Not	
Breccia	Burrow
Boring	Shrinkage

Figure 4. Choquette and Pray classification of carbonate porosity.
 (After Choquette and Pray, 1970, fig. 2, p. 224.) Only some examples of each general class of pores are given.

classification. They divided porosity into primary and secondary porosity: porosity formed before or after cessation of final deposition, respectively. Most interparticle porosity is primary and most other porosity is secondary (some skeletal debris contains significant primary intraparticle porosity). They further divided secondary porosity into three groups. Eogenetic, or early burial, processes affect pore systems when they are still near the surface; mesogenetic processes occur under conditions of deep burial; and telogenetic processes are associated with uplift of long-buried strata and their modification by fluids associated with an exposure surface. In practice the terms eogenetic, mesogenetic, and telogenetic are not always used, and pores are sometimes simply divided into primary and secondary. Porosity types were also classified on the basis of mode of genesis, size and shape, and abundance. The sizes of pores are mainly used to distinguish between microporosity and macroporosity. Choquette and Pray (1970) defined micropores as those smaller than 1/16 mm. Others use the difference between point-count (visual) and helium-core-plug porosity.

Fabric selectivity, one of the most widely applicable criteria for identifying genetic pore types, is the fundamental basis for porosity classification according to the scheme of Choquette and Pray (1970). Fabric-selective pores have shapes, sizes, and distributions that are controlled, at least in part, by the sediment or rock fabric existing when the pores formed. All primary pores and many early-formed secondary pores are fabric selective. By contrast, nonfabric-selective pores do not seem to have been affected by preexisting fabric. The pores formed by creation of a new fabric. Many mesogenetic and telogenetic pores are nonfabric selective; the most common kind is vuggy porosity. Intercrystalline pores form simultaneously with the fabric and are regarded as fabric selective. Choquette and Pray (1970) used other criteria (time and mode of genesis, size and shape, and abundance) as modifiers to the primary criterion of fabric selectivity. Fifteen basic pore types were identified (fig. 4).

The Choquette and Pray classification has been modified for use in studies of the Smackover Formation (Kopaska-Merkel, 1992). In the context of this discussion one of these modifications, which is broadly applicable and should be useful for descriptions of many kinds of pore systems, is relevant. Choquette and Pray (1970) did not classify partial molds separately from complete molds. I do so, calling them secondary intraparticle pores, for two reasons. First, moldic and secondary intraparticle pores are not simply mixed together at random. On the contrary, some reservoir rocks contain very few secondary intraparticle pores, but an abundance of particle molds (fig. 1, A). Other reservoir rocks are dominated by recrystallized particles filled with secondary intraparticle pores, but molds are quite rare (fig. 1, B). In some reservoir rocks, ooids become molds, whereas co-occurring pellets are transformed into ellipsoidal "sacks" of secondary intraparticle pores, or vice versa. Second, molds and secondary intraparticle pores differ in their petrophysical characteristics (Kopaska-Merkel, 1992). Because of these two differences, moldic and secondary intraparticle pores are recognized explicitly as distinct pore types. Further examples of various pore types were illustrated by Kopaska-Merkel (1993b).

LUCIA CLASSIFICATION

A simplified carbonate-rock classification was published by Lucia in 1983. Lucia's intent was to lump kinds of pores that had similar engineering characteristics. Lucia classified pores into interparticle pores, which are smaller than the particles (here defined to be whatever components make up the rock, be they particles in the sedimentologic sense, crystals, or other diagenetic components), and vuggy pores, which are larger than the particles. Vugs in the sense of Lucia can be in direct contact or not; in the latter case they are connected by the smaller interparticle pores. Thus, pore systems can be vuggy or nonvuggy, the latter being pure interparticulate pore systems. If they are vuggy, the vugs can be connected directly, in which case, being much larger than the interparticle pores, they predominate in the effects on fluid flow, or they can be separated by finer interparticle pore systems (table 1). Table 2 shows equivalent classes for the Choquette and Pray system and Lucia system for the common kinds of pores in the Smackover. Thin-section photomicrographs illustrating these examples appear in figure 5.

Table 1. Lucia classification of carbonate porosity.

Table 1. Lucia classification

Interparticle			vuggy	
particle size			pore connection	
fine (< 20 µm)	medium (20-100 µm)	large (>100 µm)	indirect	direct
			separate	touching

Table 2. Comparison of classifications of Choquette and Pray and of Lucia.

Table 2. Comparison of pore classifications

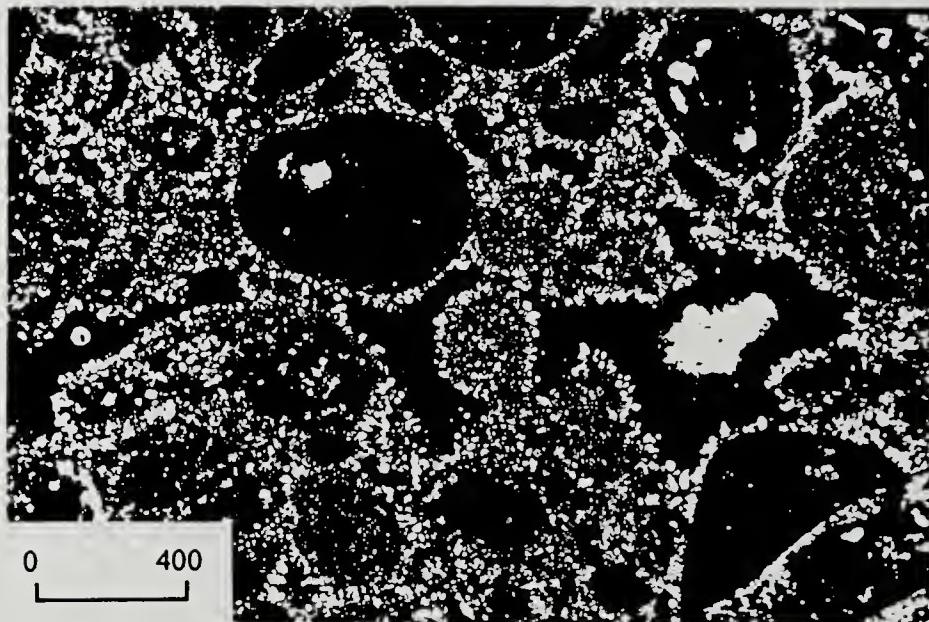
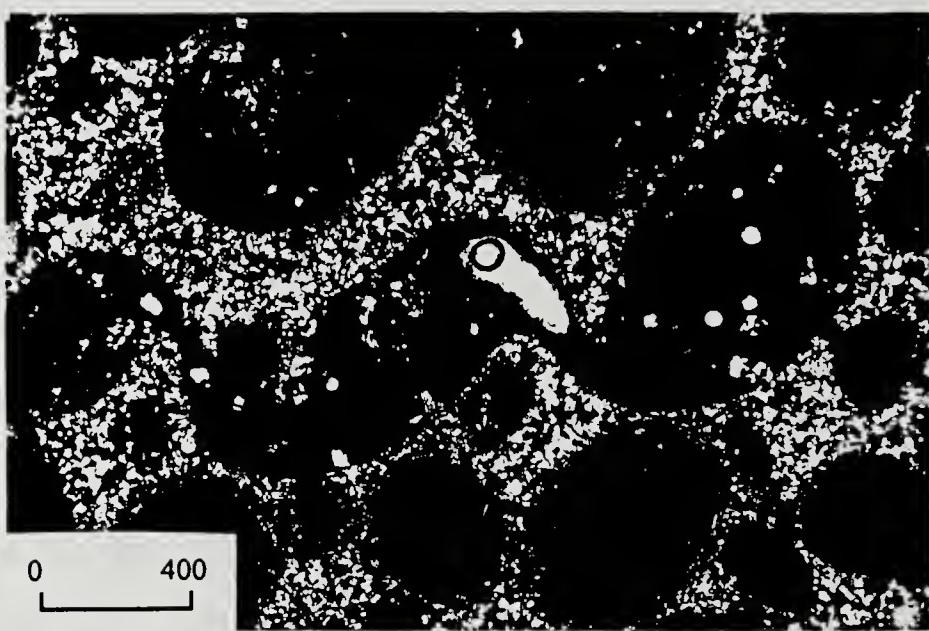
Choquette and Pray	Lucia
moldic	vuggy
interparticle	interparticle
intercrystalline	interparticle
secondary intraparticle	vuggy or interparticle

The Lucia classification is of some value in an engineering context. Sedimentological analyses, which aim to infer the origins and histories of rocks, need more detail than the Lucia classification can accommodate. For these purposes, the classification of Choquette and Pray is preferable. However, even in the context of engineering the Lucia classification is too simple for two reasons. First, interparticle pores *sensu* Lucia correspond to interparticle plus intercrystalline pores *sensu* Choquette and Pray. These two kinds of pores tend not to occur together, have different sizes and connectivities, form under different conditions and at different times, and differ in their resistance to destruction in the subsurface.

Interparticle pores *sensu stricto* exist when sediment is deposited; their story is one of progressive occlusion by cement and destruction by pressure dissolution under conditions of deep burial. One of the most-common fates to befall an interparticulate pore system is the precipitation of pore-lining cement in the subsurface (Longman, 1980). Crystals grow into pores perpendicular to pore surfaces, pore throats are almost instantly sealed off, and interparticle pores are converted into cement-reduced pores whose fluid-flow characteristics are those of isolated vugs *sensu* Lucia. Pores no longer touch one another through the medium of relatively large primary interparticle pore throats, but through tortuous pathways among the tiny cement crystals. By contrast, intercrystalline pores in carbonate rocks chiefly occur between dolomite crystals. These crystals form after burial of the sediment, and after

Visual Pore-System Analysis

formation of early cement phases. Because of this, and because dolomite is chemically resistant, intercrystalline pore systems tend to persist for long periods of time. Also, because dolomite crystals are rhombic, connectivity of intercrystalline pore-systems is high.



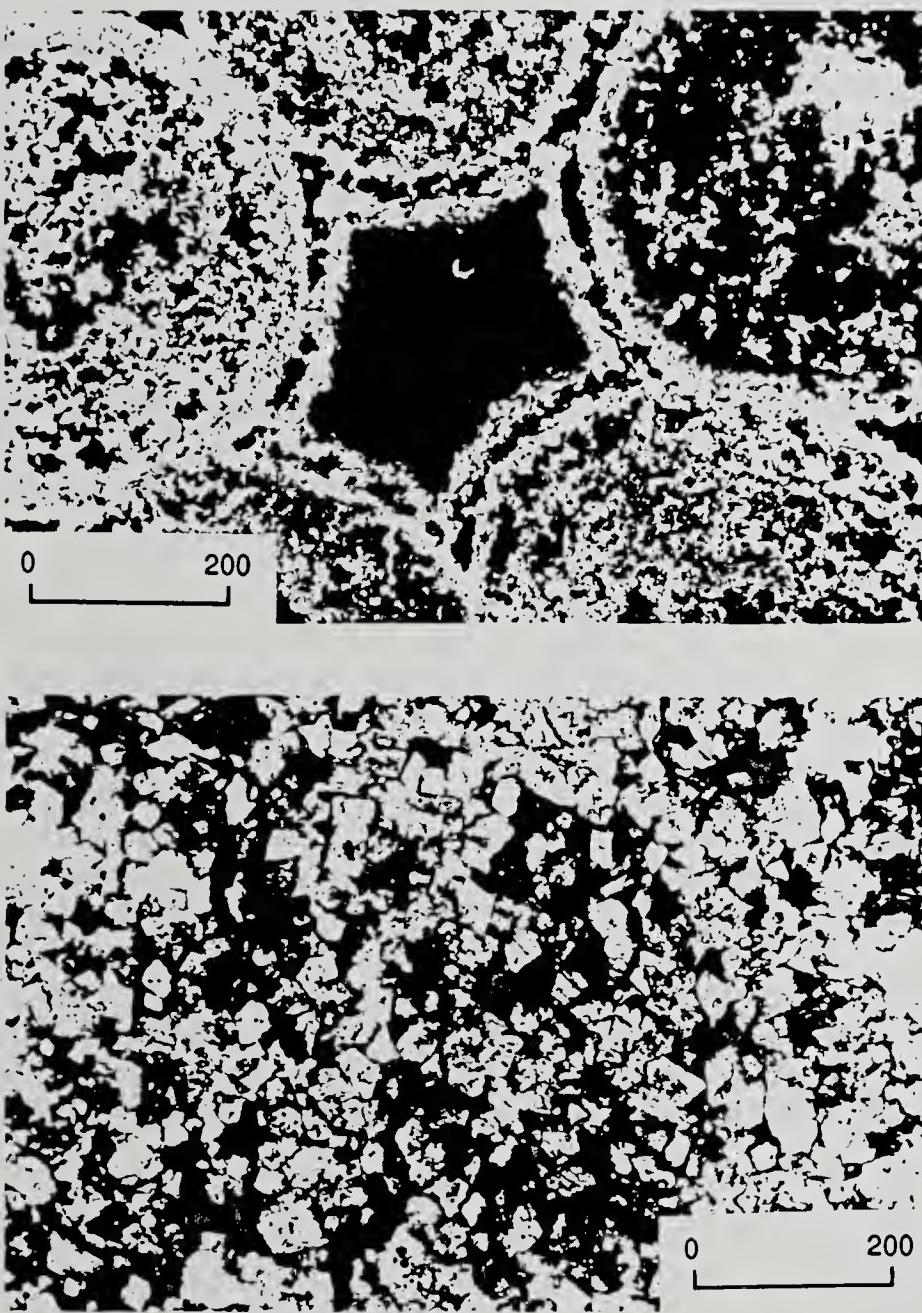


Figure 5. Thin-section photomicrographs illustrating common kinds of pore systems in the Smackover of Alabama. Dark areas are pores; white spots are nonstained epoxy in pores; scales in μm . A) Moldic; B) moldic plus interparticle; C) secondary intraparticle plus interparticle; D) intercrystalline. In (B), note nearly continuous horizontal band of primary interparticle porosity across middle of photomicrograph, with white patch of nonstained epoxy. In (C), center of view is a primary interparticle pore rimmed by a thin cement rind; the five surrounding spherical particles exhibit varying degrees of dissolution.

Visual Pore-System Analysis

Interparticle pores and intercrystalline pores tend not to occur together for the reasons outlined. Also, interparticle pores commonly co-occur with molds, formed by the dissolution of chemically unstable particles. In carbonates, interparticle pores rarely dominate a pore system (e.g., Kopaska-Merkel and Mann, 1991b), whereas primary interparticle pores are abundant in siliciclastic sandstone. By contrast, pore systems consisting almost entirely of intercrystalline pores are common in carbonates. Because interparticle and intercrystalline pores form at different times and in different ways, persist in different places and for different reasons, and are modified to different degrees in the subsurface, an understanding of their origins helps predict their distribution. This understanding is encouraged by the genetic-geometrical classification of Choquette and Pray, but not by the geometrical classification of Lucia.

GEOMETRICAL ANALYSIS OF PORE-SYSTEMS

No matter what pore-system classification has been chosen, ternary diagrams provide a powerful method of graphically displaying the data so that they can be readily understood. This applies both to nongenetic classifications and to classifications with genetic implications.

Ternary diagrams commonly are used to summarize geological data. In the earliest instance I know of in which ternary diagrams were used specifically to study porosity, Pittman (1979) estimated the relative proportions of interparticle pores, dissolutional pores, and micropores in sandstone. Despite widespread use of ternary diagrams in geology, and specifically in rock classification, the most widely accepted carbonate-rock classifications, those of Folk (1959), Dunham (1962), and Choquette and Pray (1970), are essentially tabular. The power of ternary diagrams for clearly and simply summarizing data suggests that they can play a greater role than heretofore in the classification of carbonate rocks. I use ternary diagrams to classify carbonate pore types as described below.

Ternary diagrams whose apices are pore types (ternary pore plots; Kopaska-Merkel and Mann, 1991a,b; Kopaska-Merkel, 1992) are constructed such that the three apices together account for most of the pores observed. This approach simplifies the interpretation of pore systems, by focusing on only three major components and by displaying these data on a simple graphic plot that makes trends and clustering of samples obvious. Ternary pore plots provide information on the *shapes* and *origins* of pore-system elements, and, because these factors are correlated with engineering parameters such as permeability, ternary pore plots summarize information on those characteristics as well.

For the Smackover Formation in Alabama, the three apices of ternary pore plots are: (1) moldic plus secondary intraparticle, (2) interparticle, and (3) intercrystalline (all *sensu* Choquette and Pray). Data consist of point counts of thin

sections. Thin sections, 30-micrometer-thick slices of rock on glass, are illuminated with transmitted light in a petrographic microscope. The rock is impregnated with blue epoxy, so pore space is readily visible. A grid is placed over the slide, and the nature of the rock or pore at each grid intersection is recorded. About 200 points were counted on each of more than 100 thin sections. This procedure could be automated using image analysis, at least for simple pore systems. A somewhat different method has been automated by Ehrlich and co-workers (e.g., Ehrlich and others, 1991).

Most Smackover reservoir rocks fall close to either the moldic apex or the intercrystalline apex of ternary pore plots, with most of the remaining pore systems falling between these two extremes (fig. 6). The spectrum of Smackover pore systems is not a continuum, but represents partial mixing of two distinct end members and

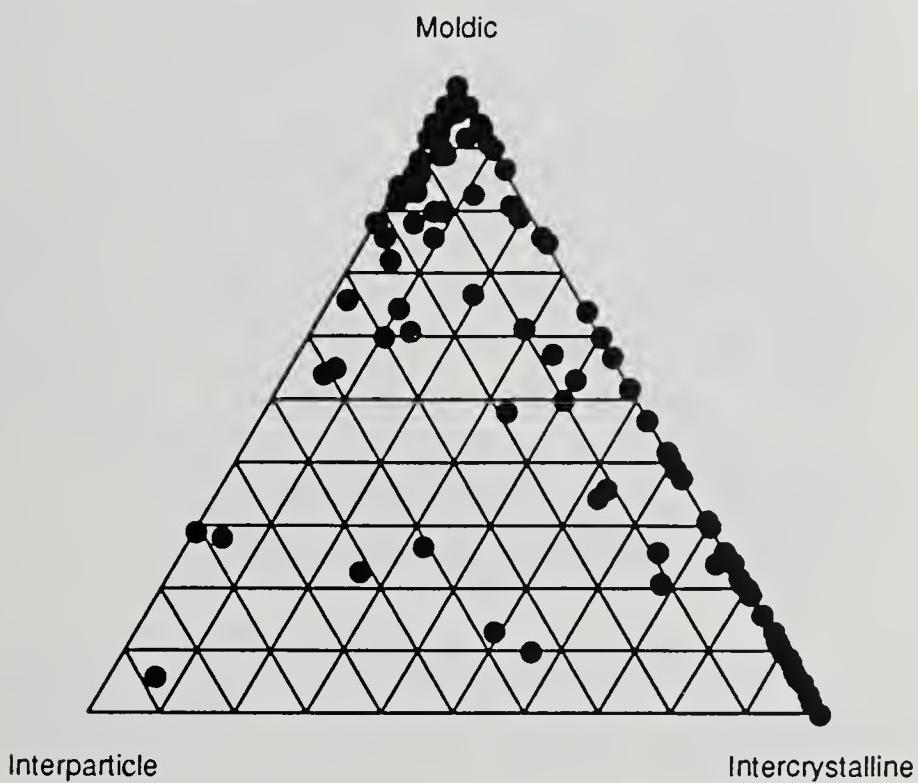


Figure 6. Ternary pore plot of more than 100 point-counted thin sections from the Smackover of Alabama (After Kopaska-Merkel and Mann, 1991b, fig. 3, p. 377).

intermediates are scarce. Two pore facies (rock units defined by the relative proportions of different kinds of pores) are recognized in the Smackover of southwest Alabama: the moldic pore facies and the intercrystalline pore facies (Kopaska-Merkel and Mann, 1991b). These are defined on the basis of the relative proportions of particle molds (including secondary intraparticle pores) and intercrystalline pores,

Visual Pore-System Analysis

which together account for greater than 85% of the total porosity in the Smackover of southwest Alabama (Kopaska-Merkel and Mann, 1991b). An arbitrary percentage of 60% of the dominant pore type has been selected as the boundary for pore facies. Intermediate pore systems are classified informally as a third pore "facies." Not only do the pore facies look different, they have different petrophysical characteristics as well (table 3). Porosity values are significantly higher in the moldic pore facies, but connectivity is better in the intercrystalline pore facies. Maximum permeability is significantly higher in the intercrystalline pore facies than in the moldic pore facies. Intermediate pore systems resemble intercrystalline ones petrophysically, except that intermediate samples yield capillary-pressure curves resembling those of both moldic and intercrystalline samples, as well as a third kind of curve (Kopaska-Merkel, 1992, 1993a).

Table 3. Characteristics of moldic, intermediate, and intercrystalline pore systems.

Table 3. Characteristics of pore systems classified according to pore type.*											
Pore-system	Kind of dolomite	Aspect ratio	Pore size	Throat size	Throat-size dist.	Mean ø**	Max. k	Slope of ø-k plot	CP curve form	MH	μH
moldic	fabric selective	high	large	very large	leptokurtic	high	low***	low	1, 3	low	high
intermediate	both	variable	variable	variable	platy- to leptok.	very low	high	high, variable	3, 4, 5	high	low
intercrystalline	nonselective	low	small	large	mesokurtic	low	high	high, variable	4	high	low

* See Kopaska-Merkel (1992) and Kopaska-Merkel and Hall (1992) for details and numerical values.
** ø=porosity; k=permeability; CP=capillary pressure; MH=megascopic heterogeneity; μH=microscopic heterogeneity
*** Excluding all samples that contain significant amounts of interparticle porosity

Using a genetic pore classification to identify different kinds of pore systems relates directly to fluid-flow characteristics. Moldic and secondary intraparticle pores differ fundamentally from intercrystalline pores. This difference has a major effect on fluid-flow properties of pore systems dominated by one or the other of these two kinds of pores. Moldic (and secondary intraparticle) pore systems are heterogeneous on a microscopic scale because they consist of large pores (or clusters or relatively large pores) that are connected to one another by distinctly different (commonly finer) pore systems. The large pores are the particle molds, and the fine pores are found in the material that has filled the original interparticle primary porosity. In the Smackover, this material is commonly either dolomitized carbonate cement (by far the most common), dolomitized lime mud, or calcium-carbonate cement. Note that pore sizes, but not necessarily pore-throat sizes, are inherently heterogeneous in the moldic pore facies. By contrast, many intercrystalline pore systems are inherently less heterogeneous microscopically, because they tend to consist of unimodal leptokurtic distributions of dolomite crystals that are all about the same shape (figs. 2 and 7). (Kurtosis refers to the breadth of a frequency distribution: leptokurtic distributions are concentrated near the mode, whereas platykurtic distributions are spread out over a wide range of values.) Moldic pore systems have a significant potential for trapping hydrocarbons within the large molds, because the high aspect ratio (pore/throat size

ratio) at the interface between the molds and the surrounding much-smaller intercrystalline pores puts stress on the continuous nonwetting phase (oil, water-wet reservoirs) (Yu and Wardlaw, 1986). This facilitates rupture of the continuous nonwetting phase, and isolated oil globules left behind in particle molds are permanently trapped. (This process is only common in water-wet systems; Morrow, 1990). By contrast, in intercrystalline pore systems, aspect ratios are relatively low and uniform, and the potential for trapping is thereby diminished. Further, intercrystalline pore systems are probably more highly interconnected than moldic pore systems, so small permeable regions that are entirely surrounded by much finer pore throats are comparatively rare. This is important, because moving fluids tend to bypass such regions.

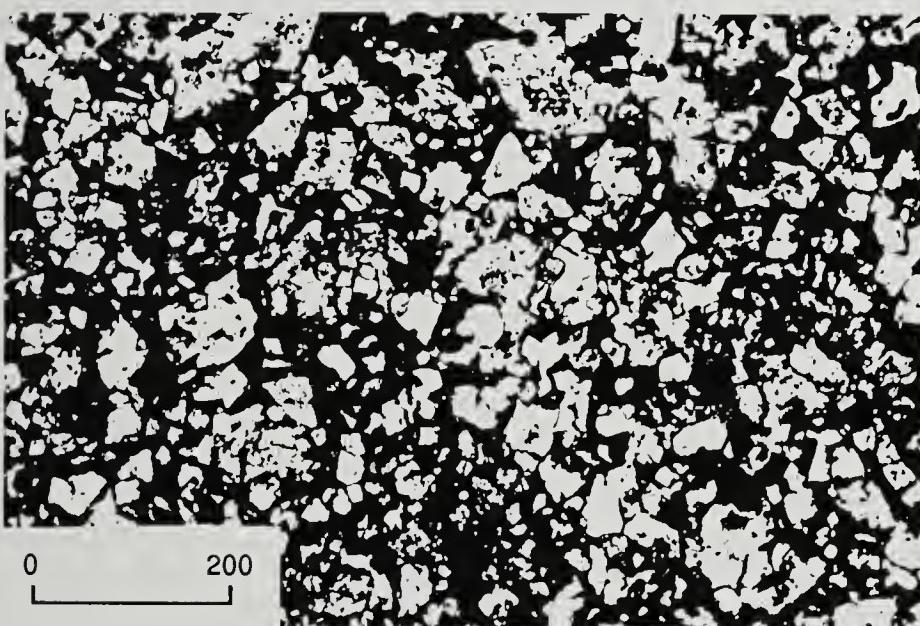


Figure 7. Planar-e dolostone with unimodal crystal-size distribution. Note rhombic crystal form. Thin-section photomicrograph; scale in μm . See figure 2 for histogram of crystal-size distribution from a similar sample.

The range of slopes of regression lines of porosity vs. permeability for the intercrystalline pore facies is much greater than for the moldic pore facies. This may be because only two processes (i.e., cementation and dissolution) operate to produce moldic pore systems, whereas a third process, nonfabric-selective dolomitization, is also important in the evolution of intercrystalline pore systems (Kopaska-Merkel and Mann, 1991b; Kopaska-Merkel, 1992). (Dolomitization *per se* had little effect on pore-system characteristics of the moldic pore facies, because pore-system characteristics were preserved along with rock fabrics by fabric-selective dolomitization. Note that here it is the *process of dolomitization* that is fabric-selective

Visual Pore-System Analysis

or not. Intercrystalline pores are always fabric-selective with respect to the fabric of dolomite crystals.) This variation in slopes of regression lines is a megascopic effect, distinct from the microscopic heterogeneity referred to above. Whereas moldic pore systems are relatively heterogeneous microscopically, just the opposite is true at megascopic scales (Kopaska-Merkel and Mann, 1992).

CONCLUSIONS

Visual pore-system analysis is an important component of the study of fluid-flow through porous media. A genetic pore-system classification that is congruent with geometrical differences among pore systems is most useful because predictivity is highest and the groups identified by the classification differ in fluid-flow characteristics. Ternary pore plots are a powerful but simple tool that can be used to summarize pore-system geometry.

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REFERENCES CITED

- Choquette, P.W. and Pray, L.C., 1970. Geological nomenclature and classification of porosity in sedimentary carbonates. American Association of Petroleum Geologists Bulletin, v. 54, p. 207-250.
- Dunham, R.J., 1962. Classification of carbonate rocks according to depositional texture, *in* Ham, W.E. ed., Classification of carbonate rocks: American Association of Petroleum Geologists Memoir 1, p. 108-121.
- Ehrlich, R., Crabtree, S.J., Horkowitz, K.O., and Horkowitz, J.P., 1991. Petrography and reservoir physics 1: objective classification of reservoir porosity: American Association of Petroleum Geologists Bulletin, v. 75, p. 1547-1562.
- Folk, R.L., 1959. Practical petrographic classification of limestones. American Association of Petroleum Geologists Bulletin, v. 43, p. 1-38.
- Friedman, G.M., 1965. Terminology of crystallization textures and fabrics in sedimentary rocks: Journal of Sedimentary Petrology, v. 35, p. 643-655.
- Friedman, G.M., Sanders, J.E., and Kopaska-Merkel, D.C., 1992. Principles of sedimentary deposits, stratigraphy and sedimentology: New York, Macmillan Publishing Co., 717 p.

Kopaska-Merkel

Kopaska-Merkel, D.C., 1991. Analytical procedure and experimental design for geological analysis of reservoir heterogeneity using mercury porosimetry. Geological Survey of Alabama Circular 153, 29 p.

_____, 1992. Geological setting, petrophysical characteristics, and regional heterogeneity patterns of the Smackover in southwest Alabama, Draft Topical Report on Subtasks 2 and 3, U.S. Department of Energy Contract No. DE-FG22-89BC14425: Geological Survey of Alabama, 207 p.

_____, 1993. Capillary-pressure characteristics of Smackover reservoirs in Alabama: Geological Survey of Alabama Circular 170, 38 p.

_____, 1993. Slide set on carbonate porosity and pore-system evolution: Geological Survey of Alabama Educational Series 1, 17 p. and 40 35-mm slides.

Kopaska-Merkel, D.C., and Hall, D.R., 1992. Reservoir characterization of the Smackover Formation in southwest Alabama: final summary topical report submitted to DOE for contract no. DE-FG22-89BC14425, Geological Survey of Alabama, 186 p.

Kopaska-Merkel, D.C., and S.D. Mann, 1991a. Carbonate pore-system analysis using ternary pore plots [abs.]: American Association of Petroleum Geologists Bulletin, v. 75, p. 613.

_____, 1991b. Pore facies of Smackover carbonate reservoirs in southwest Alabama: Gulf Coast Association of Geological Societies Transactions, v. 41, p. 374-382.

_____, 1992. Regional variation in microscopic and megascopic reservoir heterogeneity in the Smackover Formation, southwest Alabama: Gulf Coast Association of Geological Societies Transactions, v. 42, p. 1-24.

Longman, M.W., 1980. Carbonate diagenetic textures from near surface diagenetic environments: American Association of Petroleum Geologists Bulletin, v. 64, p. 461-487.

Lucia, F.J., 1983. Petrophysical parameters estimated from visual descriptions of carbonate rock: A field classification of carbonate pore space: Journal of Petroleum Technology, v. 35, p. 629-637.

Morrow, N.R., 1990. Wettability and its effect on oil recovery: Journal of Petroleum Technology, v. 42, p. 1476-1484.

Visual Pore-System Analysis

- Pittman, E.D., 1979. Porosity, diagenesis and productive capability of sandstone reservoirs, *in* Scholle, P.A. and Schluger, P.R. eds., Aspects of Diagenesis. Society of Economic Paleontologists and Mineralogists Special Publication 26, p. 159-173.
- Schlumberger, 1972. Log interpretation: volume 1 -- principles: New York, Schlumberger Ltd., 112 p.
- Sibley, D.F., and J.M. Gregg, 1987. Classification of dolomite rock textures: Journal of Sedimentary Petrology, v. 57, p. 967-975.
- Warlaw, N.C., 1976. Pore geometry of carbonate rocks as revealed by pore casts and capillary pressure. American Association of Petroleum Geologists Bulletin, v. 60, p. 245-257.
- Wardlaw, N.C., and McKellar, M., 1981. Mercury porosimetry and the interpretation of pore geometry in sedimentary rocks and artificial models: Powder Technology, v. 29, p. 127-143.
- Yu, Li and Wardlaw, N.C., 1986. The influence of wettability and critical pore-throat size ratio on snap-off: Journal of Colloid and Interface Science, v. 109, p. 461-472.

CALCULUS INSTRUCTION IN ALABAMA'S SECONDARY SCHOOLS¹

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ABSTRACT

A survey of all high school calculus teachers identified by each school system in Alabama revealed that about half of the teachers taught calculus for the specified school year, although evidence exists that the remaining teachers expected to teach calculus the following year which suggests a large increase in the number of secondary schools offering calculus. Even though most of the teachers had attended an AP training session and their classes had been identified as an advanced placement course, texts recommended by the Advanced Placement Program and the Alabama State Department of Education were not used and many students did not take the AP examinations. The study found that the preparation of these calculus teachers was questionable.

A Sloan Foundation sponsored conference on calculus at Tulane University in January, 1986, came to the conclusion that calculus instruction and the calculus curriculum were in serious need of revision and there was agreement on this need. The conferees concluded that the course content needed to be focused on the basic concepts of calculus and that the algorithmic approach to teaching calculus should be changed. The need for revision was enhanced by the development of discrete mathematics, the opportunity to seriously consider the role of computer technology in the determination of appropriate content, and recent administrative and instructional practices (Zorn, 1986). Lynn Steen (1986), President of the Mathematical Association of America, stated that the teaching of calculus was a national disgrace as evidenced by the fact that many universities reported a combined failure and withdrawal rate in excess of 50%. Gillman (1988) cited large classes, classes in excess of 100 to 200 students, as one means that universities have used to increase tuition income without a corresponding increase in cost as a contributing factor to the calculus problem.

Calculus for a New Century (1987) indicates the concerns and approaches of many groups and individuals involved in calculus reform. Among the issues raised in this report were: the problem of mathematics departments retaining their own majors in their own graduate programs which clearly impacts on the quantity and quality of

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instructors in calculus, inappropriate and poorly structured texts, the use of technology in calculus, the selection of appropriate applications for both old and new clients, the motivational level of students enrolled in calculus, and calculus as a discipline. Barry Cipra (1988) reported that many students enter college with a weak background in algebra, geometry, and trigonometry in preparation for calculus and many have had a watered down taste of calculus in secondary schools which has resulted in many students retaking calculus in college with poor results. He also asserted that there is a shortage of high school mathematics teachers prepared to teach calculus. As a consequence of these and other problems, a joint committee of the Mathematical Association of America and the National Council of Teachers of Mathematics sent a letter to high schools nationwide recommending that only students with 4 full years of college preparatory mathematics be offered calculus and that those students should be so prepared that they would not need to retake that portion of calculus in college. A summary of the curriculum recommendations of the joint committee were reported by Lichtenberg (1988). Among the conclusions reached by the committee were that the four years of precalculus mathematics should include essential content from geometry and intermediate algebra; geometry in both two and three dimensions, coordinate geometry, and the development of geometric perception; computer programming should not replace any college preparatory mathematics course; and that if calculus is taught in high school, then it should be the equivalent of a college level calculus course as exhibited by successful completion of an AP exam or a university level examination.

More recent guidelines for the preparation of mathematics teachers (National Council of Teachers of Mathematics, 1989), including calculus teachers, have been written in terms of competencies rather than courses or course structure. The Committee on the Undergraduate Program in Mathematics (CUPM) Panel on Teacher Training (1983) recommended that high school mathematics teachers complete 13 courses in mathematics (approximately 60 quarter hours of mathematics beginning with calculus) and that teachers of calculus should have additional work in analysis including background for teaching the content of advanced placement calculus. Previous recommendations (CUPM, 1961) stated that teachers of calculus should have a master's degree in mathematics with a minimum of 18 courses of college mathematics beginning with calculus.

The advanced placement program in mathematics has expanded considerably. In 1955 there were 38 schools in the country participating in the program and, in that same year, there were 285 students who took the examination (Pieters, 1961). In 1987 in Alabama alone, there were 72 schools participating in the advanced placement program in calculus as reported by the Alabama State Department of Education. This does not include those schools that teach calculus that are not under the auspices of the advanced placement program (Johnson, personal communication, 1987).

Calculus

The expansion of the advanced placement program in mathematics, the problems associated with the teaching of calculus at the college level, and the lack of any detailed description of the advanced placement program in calculus or calculus programs other than the advanced placement programs at the secondary level motivated this study. This research focuses on the expansion of the advanced placement program in calculus and other calculus programs in Alabama's high schools that impact on college calculus programs. Information regarding the following specific questions was sought:

1. To what extent are Alabama schools offering calculus, particularly AP calculus, and how many students are involved?
2. Are students actually taking the AP examinations and what are the policies associated with the decision for students to take or not take the examinations?
3. How are students performing on the advanced placement examinations?
4. To what extent are schools with advanced placement calculus programs actually following advanced placement policies including course syllabi, recommended texts, and supplemental materials?
5. What is the nature of the preparation of secondary calculus teachers?
6. Although the AP calculus program does not address the use of computers, are secondary calculus teachers incorporating computer technology into their instruction?

METHOD

To address these questions, a complete listing of school systems and schools with AP calculus was obtained with the cooperation of the Alabama State Department of Education. Not only did this provide baseline information but also an opportunity to ascertain the validity of that information. Also the State Department of Education provided complete and current information regarding the state approved advanced placement program in calculus. In the spring of 1988 each public school superintendent in the state was contacted by mail, asked to identify each high school in their district which offered calculus, and to name the calculus teacher in each school for the school year 1987-1988. All 129 school systems responded.

A questionnaire was developed and sent to chairs of the mathematics departments in three of the state's colleges and universities and three known secondary calculus teachers for their review and suggested modifications. The following school year the revised instrument was sent to each identified secondary

calculus teacher in the state. The following short answer questionnaire resulted with blanks provided for responses.

CALCULUS SURVEY INSTRUMENT

Unless specifically stated otherwise, all answers should be in terms of the 1987-1988 academic year. If you are unsure of a response, provide your best estimate.

1. Did you teach calculus in your high school in 1987-88?

Answer YES or NO

If your answer is no, you need not complete the remainder of the instrument.

2. What grade levels are included in your school, i.e. 9-12?
3. What was the total school enrollment?
4. How many calculus classes do you teach?
5. How many students were enrolled in calculus?
6. How many years of college preparatory mathematics is required for admission to your calculus program?
7. Were the calculus classes approved AP courses? Answer YES or NO.
8. If your answer to item 7 was YES, how many were AB classes?
9. If your answer to item 7 was YES, how many were BC classes?
10. How many students were enrolled in AB classes?
11. How many students were enrolled in BC classes?
12. How many students took the AP exam for AB classes?
13. How many students who took the AP exam for AB calculus made a score of 3 or more?
14. How many students took the AP exam for BC classes?
15. How many students who took the AP exam for BC calculus made a score of 3 or more?

Calculus

16. On the reverse side of this page, describe the policies regarding whether or not a student takes the AP exam.
17. On the line below, provide the bibliographic information for the text you use in your calculus course.
18. How many years has calculus been taught at your school?
19. Do you use computer technology as an integral part of the calculus course? Answer YES or NO.
20. Is the calculus class structured differently than other mathematics classes at your school? Answer YES or NO.
21. What is the calculus enrollment in 1988-89?
22. How many years have you taught calculus in this school?
23. How many years have you taught calculus at the secondary level?
24. How many years have you taught calculus at the junior college level?
25. How many years have you taught calculus at the senior college level?
26. In 1987-88, how many different preparations did you have?
27. Have you attended training sessions for AP calculus?
28. What was the date of your most recent training session?
29. What was the length of your AP training session?
30. How many computer languages do you know well enough to include in your instruction in calculus?
31. Do you have computer facilities available for your instruction in calculus?
32. If you have microcomputers available regularly for use in your calculus classes, how many computers do you have?
33. If you have other computers available for calculus, describe below.
34. Do you believe that computers should be a part of the calculus instruction program?

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35. Discrete mathematics is proposed as one alternative to the current calculus program. How many graduate courses have you taken in discrete mathematics?
36. Given your students, do you believe that a course other than calculus would be more appropriate given their preparation and career goals?
37. If your answer to item 36 is YES, describe on the reverse side of page 1 the nature of the course which you have in mind.
38. What is your most advanced certification level in MATHEMATICS?
39. How many courses in advanced calculus, real variables, or complex variables have you taken?
40. Below list your degrees with dates, institutions, and number of hours of mathematics.
41. If possible, enclose your syllabus for calculus.
42. On the reverse side of page 2, identify any non-computer based resource material which you use in your calculus class.
43. On the reverse side of page 2, identify computer based resource material which you use in your calculus class.

RESULTS

Forty of the 62 city systems and 28 of the 67 county systems 52.7% of the public school systems in Alabama, reported that they provided calculus instruction at the secondary level. There were 118 schools with calculus classes in these 68 school systems. Each identified calculus instructor was sent the questionnaire with a cover letter. A follow-up letter and/or telephone contact was made to teachers who could not be identified as initial respondents. The questionnaire did not require that the teacher identify themselves or the school district; however, if the respondent wished to receive the results, the cover letter had to be returned. Of the 118 questionnaires mailed, there were 86 (72.9%) responses. Eliminating those individuals (47) who asked for the results, a follow-up telephone contact was made to 10 randomly selected teachers to ascertain if they had responded and, if not, their reasons for non-response and to determine their situation. Of the 86 responses, 50 teachers taught calculus for the specified year and the remaining 36 teachers did not teach calculus in contradiction to the school system report (see Table 1) although many of them indicated that they expected to teach calculus the following year.

Calculus

The Alabama State Department of Education reported that advanced placement calculus was offered by 72 school systems. The identified teacher in each of 7 schools in 7 different school systems stated that the school did not offer calculus. It is impossible to know how many of the remaining 65 schools offered AP calculus or non-AP calculus since individual teachers could only be identified if they requested a copy of the report.

Table 1. Teacher Respondents and Frequency of Calculus Instruction

Group	AP	Non AP	Either	No Calculus	No Response
Initial	41	8	1	36	32
Follow up	4	1	0	5	

Table 1 also provides information regarding the telephone follow-up of 10 teachers. Six of these teachers had responded to the original questionnaire and 4 had taught calculus during that school year and 2 had not. Of the remaining 4 non-respondents, 3 teachers stated that their reason for non-response was that they did not teach calculus, and the other did teach calculus at the school but she had replaced another calculus teacher during the summer interval and did not have all of the requested information. In the follow-up survey, all teachers indicated that there were plans to offer calculus in their school the following year which probably indicates why the teacher had been identified by the school system. Since there were 50 calculus teachers identified for the given school year and, if the follow-up study is reasonably accurate, 25% of the non-respondents were also calculus teachers. This implies that there were approximately 58 calculus teachers in the state's high schools in 1987-88 and this number would likely have doubled in 1988-89.

Each respondent was requested to report the number of years that calculus had been taught at that school. The number of years and frequencies were 1-5, 2-7, 3-4, 4-3, 5-4, 6-4, 7-4, 8-4, 9-1, 10-5, 11-1, 12-4, 14-1, 20-1, and 25-1. These results indicate that there has been a steady increase in the number of schools offering calculus from 1975 to 1987.

Data regarding the type of school organization, average school enrollment, number of calculus classes, number of schools offering calculus, and the number of calculus students enrolled are reported in Table 2. There were 1067 students enrolled in 68 calculus classes in 1987-88 and at least 964 students were projected for enrollment in 1988-89. These schools tended to be organized in a grade 9-12 configuration and were the larger schools.

Table 2. School Organization and Enrollment, Class and Calculus Enrollment

School Organization	Mean Enrollment	<u>AP Calculus</u>		
		No. of Schools	No. of Classes	No. of Students
1-12	850	1	1	8
7-12	2292	4	4	37
9-12	1115	32	43	761
10-12	866	4	4	28
TOTAL		41	52	834
<u>Non-AP Calculus</u>				
1-12	880	2	2	20
9-12	845	6	13	193
TOTAL		8	15	213
<u>Type of Calculus Not Reported</u>				
9-12	920	1	1	20

The mean number of years of college preparatory mathematics required for admission to AP calculus was 3.6 years and 2.7 years for non-AP calculus. These means are substantially below the recommended 4 years.

The type of advanced placement program and the number of classes of each type are reported in Table 3. There were some few schools which offered both the AB and BC programs.

Table 3. Type and Frequency of Advanced Placement Classes by School

Number of Classes	AB	BC
1	33	5
2	4	0
3	2	0
Total	47	5

Calculus

The number of students enrolled in each type of program is provided in Table 4. Of 714 students enrolled in AB classes, 245 (34.3%) took the advanced placement examination and 127 (51.8%) of those scored a 3 or better. Overall 17.7% of the students enrolled in AB calculus took the exam and passed. Only 8 (6.6%) of the 120 students enrolled in BC calculus took the exam and 7 of these passed.

Table 4. Enrollment in AB and BC Programs by School

Calculus Enrollment	<u>Advanced Placement Program</u>	
	AB	BC
1 - 5	6	0
6 - 10	7	1
11 - 15	9	0
16 - 20	6	2
21 - 25	3	0
26 - 30	3	0
31 - 35	1	1
36 - 40	2	1
41 - 45	0	0
> - 45	2	0
Actual Mean	15.1	24.0

Each of the 41 AP teachers were asked to indicate the policy regarding whether or not the students were required to take an advanced placement exam. Eight teachers did not respond or the response was vague, 3 teachers required students take the exam, and 30 teachers left that decision up to the student.

Only 8 of the 41 AP teachers reported using a text identified in the advanced placement manual provided by the State Department of Education although there are other texts endorsed by the College Board which were not on the state list. The most frequently used text ($n=6$) was that by Thomas. From the course syllabi submitted, there was no discernable pattern or commonality.

Teachers reported their previous experience teaching calculus at that school, any high school, and the college level. Although there were two items that separated junior college instruction from college level instruction, the same teachers responded congruently to both questions.

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Table 5. Experience Teaching Calculus

Years Experience	Current School	Any High School	College
0 - 1	3	3	43
2 - 3	23	22	3
4 - 5	9	9	0
6 - 7	6	6	3
8 - 9	4	3	0
10 - 11	4	4	0
12 - 13	3	2	0
14 - 15	1	2	0

Since earlier guidelines on the preparation of calculus teachers gave particular attention to preparation in analysis, teachers were asked to report the number of courses taken in advanced calculus, real variables, and complex variables. In addition they were to report the number of graduate courses completed in discrete mathematics since there are proposals to alter the calculus program to more of a discrete orientation.

Table 6. Graduate Courses in Discrete Mathematics and Courses in Analysis

Number of Courses	Frequency	
	Discrete Mathematics	Analysis
No Response	3	7
None	29	1
1 - 2	13	11
3 - 4	2	14
5 - 6	3	8
7 - 8	0	4
9 - 10	0	4
> 10	0	1

Calculus

Information was sought regarding the certification level and training in mathematics and the teachers' participation in AP training. Forty-three of 49 respondents had participated in an AP training program. As of 1979 in Alabama, a Class B certificate requires a bachelor's degree with a minimum of 40 quarter hours of mathematics, a Class A certificate requires a Class B certificate plus a master's degree which includes a minimum of 20 quarter hours of graduate mathematics, and a Class AA certificate requires a Class A certificate in mathematics plus an additional 45 quarters hours of graduate study including an additional 20 quarter hours of graduate mathematics. It should be emphasized that these are the minimum number of hours required and policies of individual institutions may require considerably more than the minimums. Four teachers did not provide information on their certification, 11 had a Class B certificate, 22 a Class A certificate, 13 a Class AA certificate each in mathematics. Three teachers did not report their college degree. Of the remaining teachers, there were 6 bachelor's degrees, 28 master's degrees, 13 teachers had work beyond the master's including two working towards the doctorate.

Provision was made for the teacher to identify the degree, the name of the degree granting institution, the date of the degree, the number of hours of mathematics completed in each degree program, and if the teacher had taken courses beyond their last degree. From this information, it was possible to estimate the number of hours in mathematics in quarter hours. Perusing the data, it appears that there were some inconsistencies in the teachers' responses and this is an obvious limitation of the study. The mean number of total hours, undergraduate and graduate, in mathematics reported was 79.

Table 7. Academic Training in Mathematics and Degree Granting Institution

Institution	Number of Teachers	Range in Hours of Math	Mean ^a Hours of Math
Bachelor's Degree			
Alabama	7	^b - 77	53
Athens	4	32 - 63	43
Auburn	1	- 55	55
B'ham Southern	2	30 - 67	49
Jacksonville	6	44 - 53	48
Livingstone	1	- 44	44
Montevallo	3	45 - 59	46
North Alabama	2	54 - 60	57

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Samford	1	- 50	50
South Alabama	2	30 - 65	48
St. Bernard	2	- 52	52
Troy	5	45 - 55	48
UAB	3	27 - 55	40
UAH	1	- 40	40
Out of State	6	30 - 67	40
Mean of Individual Scores			49

Master's Degree			
Alabama	5	18 - 27	22
Alabama A & M	4	0 - 42	21
Auburn	2	30 - 60	45
Jacksonville	2	0 - 22	11
Montevallo	4	0 - 27	16
North Alabama	4	14 - 45	22
Samford	1	45	45
South Alabama	1	12	12
Troy	2	25 - 45	35
UAB	12	0 - 59	18
UAH	2	50 - 59	55
Out of State	1	63	63
Mean of Individual Scores			25

Mathematics Beyond Master's Degree			
Alabama	2	14 - 18	16
Alabama A & M	1	3	3
Auburn	2	15 - 68	41
Montevallo	2	14 - 22	18
North Alabama	2	9	9

Calculus

Troy	1	35	35
UAB	6	0 - 27	15
Out of State	1	36	36
Mean of Individuals			22

^aMean computed only on available scores.

^bUnable to determine minimum hours because of non-response.

The number of preparations of a teacher may influence not only the quality of instruction but also whether or not the teacher will have the time or energy needed to study new topics such as computers or discrete mathematics. The number and frequency of preparations were 2 preparations - 2, 3 preparations - 25, 4 preparations - 12, 5 preparations - 8, and more than 5 preparations - 2. It is difficult to see how a teacher could adequately prepare a calculus class if the teacher has more than 3 preparations.

Information regarding the role and use of computer technology in calculus instruction was sought. Thirty-three teachers (66%) indicated that computers should be a part of the calculus program. Microcomputer facilities were available to 32 teachers and another 3 teachers indicated that they had other computer facilities. The number of microcomputers available to the remaining 29 teachers are provided in Table 8. When asked if computer technology was an integral part of their program, only 10 teachers indicated affirmatively. One possible reason for the lack of use of computers is that 21 teachers did not respond to a question which asked for the number of computer languages known by the teacher, 18 teachers indicated that they did not know any programming language, and 6 teachers reported knowledge of a single language.

The secondary calculus teachers who reviewed the initial draft of the questionnaire requested an item to determine if high school calculus was structured differently than the other mathematics courses in the school and 44% of the responses were affirmative although it is not clear what this means. When asked if some courses other than calculus would be more appropriate for their students, only 3 teachers preferred some other course and there was no agreement among the three teachers about the nature of the alternative course.

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Table 8. Number of Microcomputers Available for Calculus Instruction

Number of Computers	Frequency
1	11
3	1
4	1
7	1
8	2
12	1
14	1
15	3
16	1
20	1
22	1
24	1
25	1
30	3

DISCUSSION

Calculus programs in the secondary schools are increasing at a substantial rate. Although there is extensive criticism of the calculus programs, there is little indication that the secondary calculus teachers in this survey desire any substantial change in the program. Few of these teachers have taken graduate courses in discrete mathematics. Almost 2/3 of the teachers indicated that computers should play some role in calculus instruction. However, 21 of 50 teachers did not respond to an item seeking information on teacher's knowledge of computer programming; more than 1/3 of the respondents did not know a single programming language. This lack of computer knowledge may account for the result that only 20% of the respondents considered computers to be an integral part of their calculus course. It is possible that the teachers might be able to use some existing software in calculus instruction; however, the number of available computers and the class size could mitigate against such usage.

Calculus

Evidence exists to suggest that policies associated with the advanced placement program are not being followed with the exception of teacher participation in advanced placement training programs. Although the State Department of Education and the AP program recommends texts, many of the teachers did not use such texts. The failure of AP calculus students to take the advanced placement exams is of even greater concern. These examinations are critical to the quality control of the advanced placement programs and the lack of quality control contributes support to the charges of Cipra (1988). Teachers were not asked if the students were required to take university level calculus examinations.

There is clear conflict between the recommendations of the Joint Committee (Lichtenberg, 1988) and the practices of these schools regarding the mathematical preparation of students to take calculus. The AP calculus teachers and the non-AP calculus teachers reported 3.6 and 2.7 years respectively of college preparatory mathematics as a requirement for a student to enroll in calculus.

The mathematical preparation and teaching load of high school calculus teachers continues to be of concern. The number of preparations likely influences the teacher's planning and instruction. The mean of 72 quarter hours of mathematics completed by these teachers would be about 18 courses and in the range of the minimum number of courses recommended by CUPM 1961) although not necessarily beginning with calculus. But is the glass half full or half empty since this would infer that about half the teachers would not have met the minimum? Similarly only about 50% of these teachers reported that they had taken 4 or more courses in analysis. The author suspects that the frequency of calculus teachers graduating from the various institutions reflects policies and views of faculty members of the institutions. Any resolution of the problems in calculus will have to include high school teachers.

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REFERENCES

- Committee on the Undergraduate Program in Mathematics. (1961).
Recommendations for the training of teachers of mathematics. Berkeley, CA:
Mathematical Association of America.
- Committee on the Undergraduate Program in Mathematics. (1983).
Recommendations on the mathematical preparation of teachers. Washington,
DC: Mathematical Association of America.

Easterday

- Cipra, B. (1988). Calculus: Crises looms in mathematics' future. *SCIENCE*, 239, 1491-1492.
- Gillman, L. (1988). The college teaching scandal. *FOCUS*, 8,(2), pp. 2,5.
- Lichtenberg, D. R. (1988). Curriculum recommendations grades 11-13: The NCTM/MAA task force report. *FOCUS*, 8(10). pp. 1,5.
- National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.
- Pieters, R. S. (1961). The advanced placement program in mathematics. *Mathematics Teacher*, 54, 201-211.
- Steen, L. A. (Ed.). (1989). *Calculus for a new century: A pump not a filter*. Washington, DC: Mathematical Association of America.
- Steen, L. A. (1986). Taking calculus seriously. *FOCUS*, 6,(2), 4.
- Zorn, P. (1986). Calculus redux. *FOCUS*, 6(2), 1-2.

SYNTHESIS, STABILITY AND ANALYTICAL PROFILES OF 3, 4-METHYLENEDIOXYAMPHETAMINES: DERIVATIVES OF "ECSTASY" (MDMA)¹

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INTRODUCTION

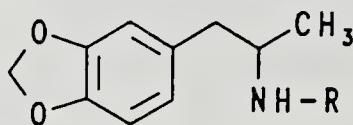
The various N-substituted derivatives of 1-(3,4-methylenedioxypheyl)-2-propanamine (3, 4-methylenedioxymphetamine, MDA) have been popular drugs of abuse in the past decade (1-3). The N-methyl derivative, 3,4-methylenedioxymethamphetamine (MDMA, "Ecstasy", "XTC") is perhaps the most widely abused drug of this series. MDMA is reported to have the unique ability to facilitate interpersonal communication by reducing the anxiety and fear that normally accompanies the discussion of emotionally painful events (4). MDMA has been suggested to represent a new pharmacological class distinct from both hallucinogenic agents and stimulants such as amphetamine and cocaine. This new class is described as entactogens - compounds that produce a "touching within". MDMA is one of several designer drugs of the MDA class that are currently popular in certain segments of the population (5).

Biochemically MDMA is thought to release serotonin and, to a lesser extent, dopamine in the central nervous system (6-8). Some reports (9, 10) have suggested that MDMA is a potent neurotoxicant that may cause selective degeneration of brain serotonin neurons and, after repeated administration, produces a long term depletion of serotonin markers in experimental animals and a reduction in serotonin receptor sites (11).

In rats, behavior characteristic of the serotonin syndrome such as low body posture, repetitive treading of the forepaw, head weaving and resting tremors (12),

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locomotor activity and autonomic signs of piloerection and salivation occur with MDMA administration in a dose related manner (12, 13). Subchronic injections of MDMA have been used in animals to compare acute versus chronic effects on these same behaviors. Both the serotonin syndrome and locomotor behavior were augmented with repeated intermittent administration (13). This latter observation parallels that observed with amphetamine (sensitization) indicating that MDMA, like amphetamine, is capable of producing behavioral sensitization.



MDA : R = H

MDMA : R = CH₃

MDE : R = CH₂CH₃

N-OHMDA : R = OH

In recent years other "designer drug" analogues of MDA including the N-ethyl (MDE) and N-hydroxy (NOHMDA) have also been encountered in forensic samples and appear to possess pharmacological activities comparable to MDA and MDMA. The continued designer-drug exploration of the MDA series has resulted in legislation in recent years to upgrade the penalties associated with the clandestine synthesis and abuse of these compounds.

EXPERIMENTAL

Instrumentation. The liquid chromatograph consisted of a Laboratory Data Control Constametric 3000 pump, 3100 Spectromonitor UV detector operated at 280 nm, CI 4100 Integrator and a Rheodyne 7125 Injector. Infrared spectra were recorded on a Perkin-Elmer Model 1710 Fourier transform infrared (FTIR) spectrophotometer. Ultraviolet spectra were recorded on a Shimadzu Instruments Model UV-160 spectrophotometer. Nuclear magnetic resonance spectra (¹H) were determined using a Varian EM-360 60 MHz Spectrometer.

The electron impact (EI) mass spectra were obtained using a Hewlett-Packard 5970B mass selective detector. The ionization voltage was 70 eV and the source temperature was 220° C. The individual amine hydrochlorides were dissolved in methanol (1 mg/mL) and 0.5 uL introduced into the mass spectrometer via a gas chromatograph equipped with a 12m X 0.31 mm i.d. fused silica column with a 0.52 um thickness of OV-1. The column temperature was programmed from 70° C to 150° C at a rate of 15° C/min and from 150° to 250° C at a rate of 25° C/min and the split ratio for the GC was 10:1.

Derivatives of "Ecstasy" (MDMA)

Liquid Chromatographic Procedures. The analytical column was 30 cm X 3.9 mm i.d. packed with uBondapak C₁₈ (Waters Associates). The analytical column was preceded by a 7 cm X 2.1 mm i.d. guard column packed with CO:Pell ODS (Whatman). The amine hydrochlorides (1 mg/mL) were dissolved in HPLC grade methanol and separated using a mobile phase of pH 3.0 phosphate buffer, methanol, acetonitrile and triethylamine (600:100:25:1). The pH 3.0 phosphate buffer was prepared by mixing 9.2 g monobasic sodium phosphate (NaH₂PO₄) in 1 L of double-distilled water and adjusting the pH to 3.0 with H₃PO₄. The mobile phase flow rate was 1.5 mL/min and the detector was operated at 0.2 AUFS. A 15 uL aliquot of each amine solution was injected into the liquid chromatograph.

Synthesis of N-Substituted MDA derivatives by Reductive Amination. A solution of 1-(3,4-methylenedioxymethyl)-2-propanone (10 mmol), ammonium acetate or alkyl-amine (100 mmol) and sodium cyanoborohydride (25 mmol) in methanol (25 mL) was stirred at room temperature for 24 h. The reaction mixture was then evaporated to dryness under reduced pressure and the remaining residue was suspended in dichloromethane (50 mL). The dichloromethane suspension was extracted with 3N HCl (2 X 75 mL) and the combined acid extracts were made basic (pH 12) with sodium hydroxide. The basic aqueous suspension was then extracted with dichloromethane (2 X 100 mL) and the combined organic extracts were dried over anhydrous Na₂SO₄. Filtration, followed by evaporation of the filtrate solvent under reduced pressure, gave the product amines in free base form. Treatment of the bases with ethereal HCl afforded the product amines as the hydrochloride salts and these were recrystallized from mixtures of anhydrous ether and absolute ethanol. The structures of the products were confirmed by IR (KBr) and ¹H-NMR (DMSO-d₆). The purity of the products was established by GC-MS and the liquid chromatographic analyses.

Synthesis of N-Hydroxy-MDA (N-OHMDA). A solution of 1-(3,4-methylenedioxymethyl)-2-propanone (1.0 g, 5.6 mmol) and hydroxylamine hydrochloride (1.0 g) in a solvent mixture of ethanol (5.0 mL) and pyridine (5.0 mL) was stirred at reflux for 2 hr. The reaction mixture was evaporated *in vacuo* and the remaining oil triturated with water to yield the intermediate oxime. The oxime was isolated by filtration, washed with water and recrystallized from ethanol/water. The dried oxime (0.5 g) and sodium cyanoborohydride (0.25 g) were dissolved in methanol (10 mL) and stirred at room temp for 3 days. Concentrated HCl (1 drop) was added to the reaction mixture every 12 hrs. The reaction mixture was evaporated *in vacuo* and the remaining residue suspended in 3N HCl (50 mL). This suspension was extracted with dichloromethane (2 X 50 mL), then the aqueous solution made basic (pH 12) by the addition of sodium hydroxide pellets. The aqueous base suspension was extracted with dichloromethane (3 X 75 mL) and the combined dichloromethane extracts evaporated under reduced pressure to yield N-OHMDA as the free base. Treatment of the base with ethereal HCl afforded the product as the hydrochloride salt which was recrystallized from a mixture of anhydrous ether and absolute ethanol.

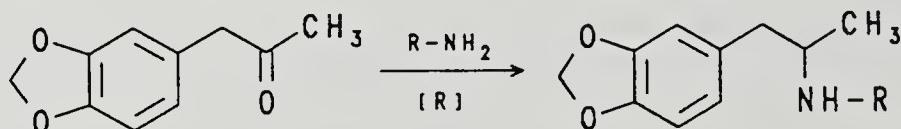
The structure of the product was confirmed by IR (KBr) and $^1\text{H-NMR}$ (DMSO-d_6). The purity of the product was established by GC-MS and the liquid chromatographic analyses.

Synthesis of MDMA from Sassafras Oil (Safrole). Samples of sassafras oil or alkenes (5.0 g of safrole, isosafrole, eugenol, isoeugenol, etc) in 48% HBr (25 mL) were stirred at room temperature for 7 days. The reactions were then quenched with the addition of crushed ice (25 mL) and extracted with ether (2 X 50 mL). The ether extracts were evaporated to dryness under reduced pressure and the resultant product oils analyzed directly. The crude bromination products (2.0 g) were dissolved in methanol (100 mL) containing 40% aqueous methylamine (20 mL) and stirred at room temperature for 4 days. The reaction mixture was evaporated to dryness and the resultant oil dissolved in 10% HCl (50 mL). The aqueous acid solution was washed with ether (2 X 50 mL) and then made basic (pH 12) by the addition of NaOH pellets. The aqueous base solution was extracted with ether (2 X 50 mL) and the combined ether extracts evaporated to dryness under reduced pressure. The resulting oil was analyzed directly.

RESULTS AND DISCUSSION

Clandestine Synthesis of MDA and MDA Derivatives

A variety of methods have been reported for the synthesis of MDA, MDMA and related compounds (14,15). The most direct approach involves treatment of the commercially available ketone 1-(3,4-methylenedioxyphenyl)-2-propanone (3,4-methylenedioxyphenylacetone) with an amine under reducing conditions as shown in Scheme 1. With this method, MDA, MDMA and the N-ethyl derivative MDEA are obtained directly in a single step. The structurally unique member of this series, N-

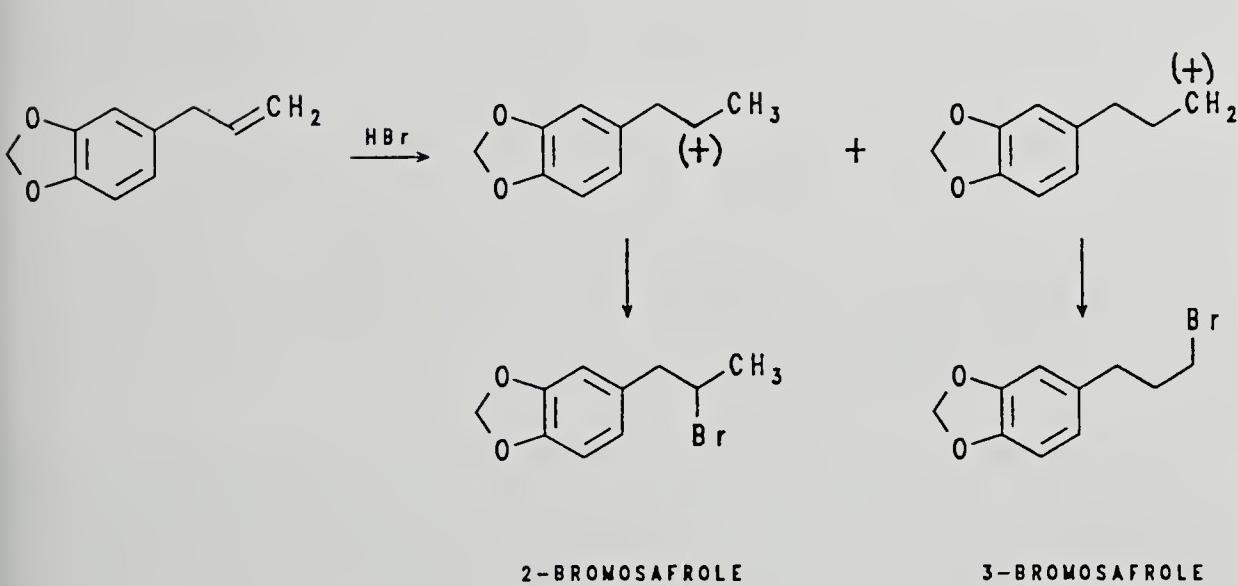
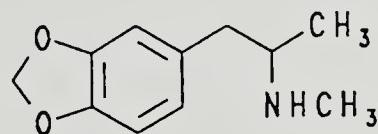
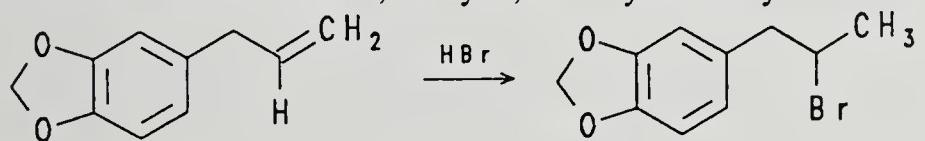


Scheme 1. Synthesis of MDA derivatives by reduction amination

OHMDA, is prepared by reduction of the oxime formed from reaction of hydroxyamine with 3,4-methylenedioxyphenylacetone. Based on this synthetic strategy, the availability of the ketone was controlled by the Drug Enforcement Administration under the Chemical Diversion and Trafficking Act in March of 1989. The restricted availability of the key ketone precursor has forced clandestine laboratory operators to seek alternative approaches for the synthesis of MDA and MDMA. One such unique approach to the synthesis of MDA derivatives employs the natural product safrole which is commercially available or can be obtained by extraction or distillation of the sassafras plant native to the US. Safrole may be used

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to synthesize the ketone *β*-(3,4-methylenedioxyphenyl)-2-propanone, or may be brominated with hydrobromic acid to yield 2-bromosafrole which can be converted to MDA or MDMA by direct displacement with ammonia or methylamine, respectively (Scheme 2). It appears that this latter approach was being employed by the operator of a clandestine laboratory seized recently. In this laboratory safrole was obtained by steam distillation of the roots of the sassafras plant, and then treated with HBr to generate 2-bromosafrole. The oil extract of sassafras bark is reported (16) to consist of about 80% safrole, 4-allyl-1,2-methylenedioxobenzene.



Scheme 2. Synthesis of MDMA from safrole

The chromatogram in Figure 1 shows the gas chromatographic analysis of the sassafras oil sample obtained from the clandestine laboratory. The total ion chromatogram (TIC) trace was obtained using a 12 m X 0.20 mm id fused silica column with a 0.33 micron thickness of methylsilicone (HPI), programmed from 70° C to 150° C at a rate of 15° C per minute and from 150° C to 250° C at a rate of 25°

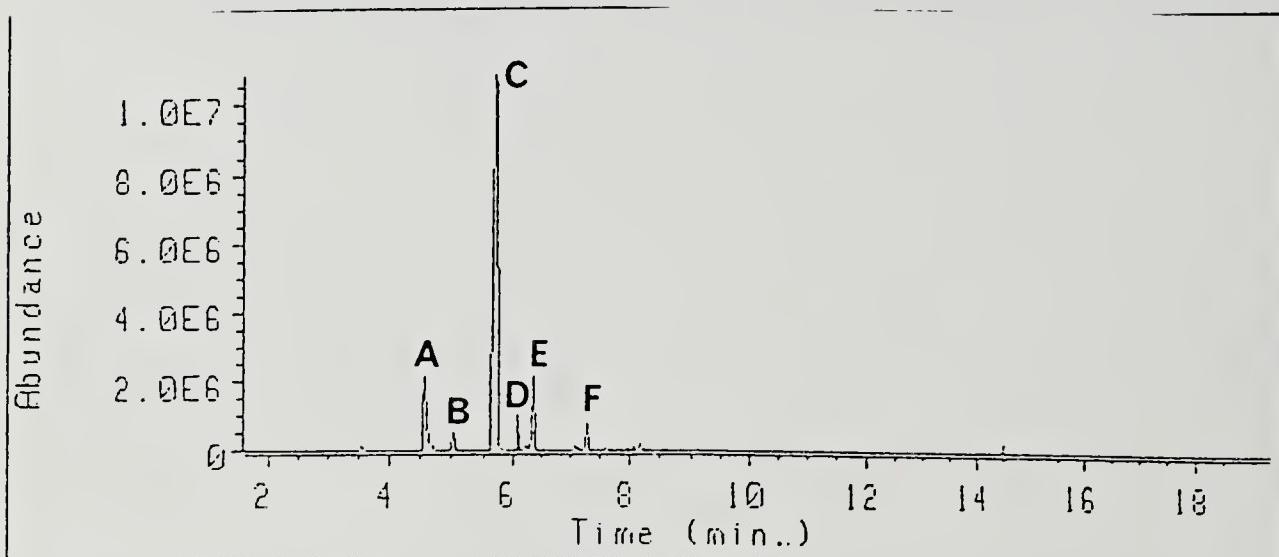


Figure 1. Gas chromatographic analysis of sassafras oil distallate

C per minute. The major component in this sample at 5.686 minutes (peak C in Figure 1) matches both the chromatographic properties and the mass spectrum for safrole (4-allyl-1,2-methylenedioxybenzene). Figure 2 shows the mass spectrum (2a) and the chromatogram (2b) obtained from the analysis of an authentic sample of safrole. These data were obtained under conditions identical to those used for the analysis of the sassafras oil distillate. This volatile organic sassafras extract contains other substituted allyl-benzenes such as eugenol and 4-allyl-1, 2-dimethoxybenzene. Several other aromatic compounds were tentatively identified based on mass spectral data. Literature reports [16,17] on the oil of sassafras bark indicate safrole as a major component (approximately 80%) with smaller amounts of pinene, eugenol, camphor and phellandrene.

A second sample obtained from the clandestine laboratory was reported to be the result of hydrobromic acid (HBr) treatment of the sassafras distillate. The chromatogram obtained from the GC-MS analysis of the HBr treated sassafras oil is shown in Figure 3a. The mass spectra of the individual peaks in this chromatogram indicates the presence of several brominated products as well as other non-brominated compounds.

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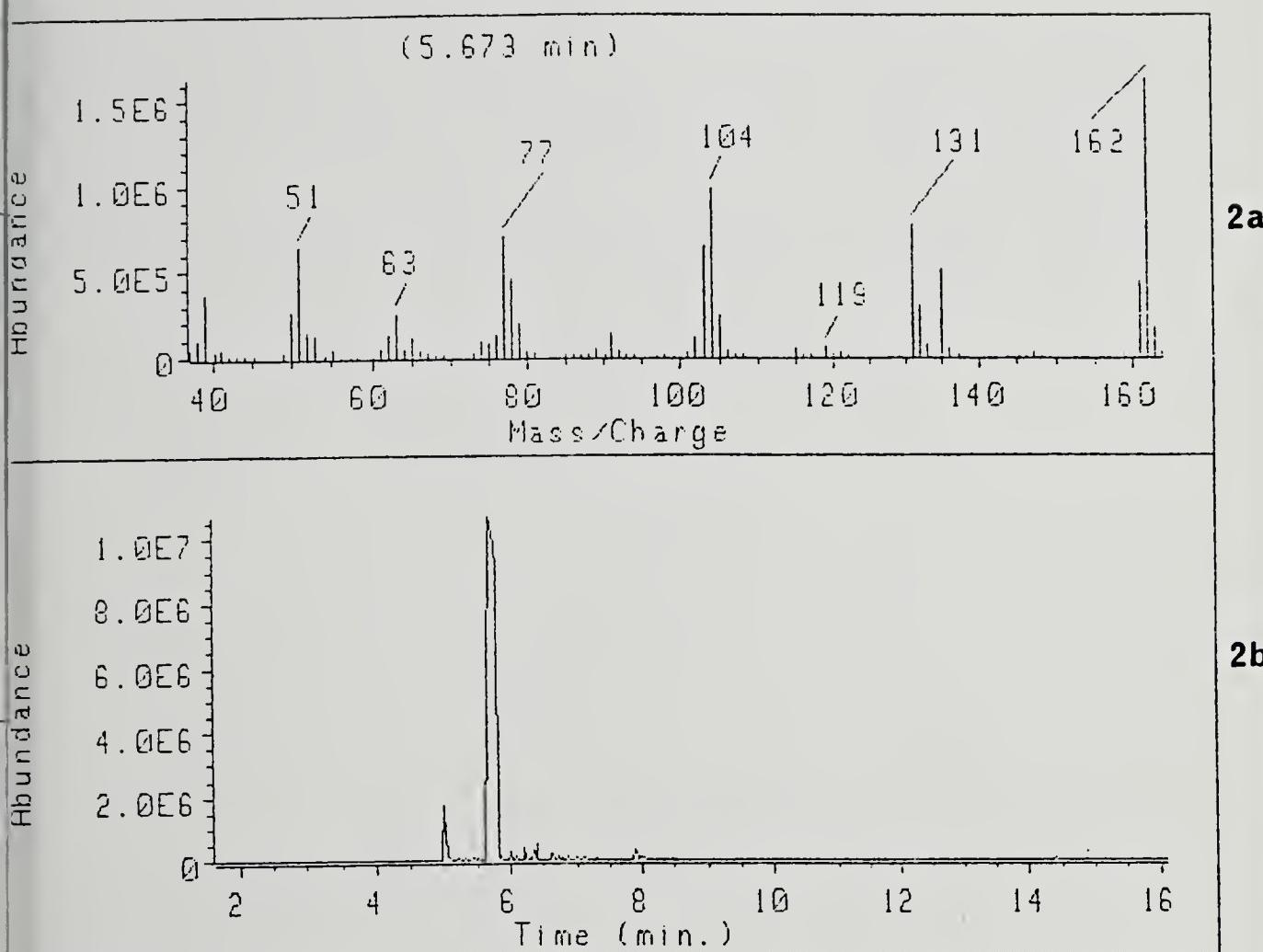


Figure 2. GC-MS analysis of an authentic sample of safrole

The major component in the HBr treated sassafras oil sample (Peak G in Figure 3) has a retention time for 7.580 minutes, a molecular weight of 242 and contains one bromine atom. A second peak at 7.781 minutes (Peak H), which is only partially resolved from the major component, also contains one bromine atom and has a mass of 242. These peaks both give mass spectra (Figures 3b and 3c) consistant with the addition of HBr to safrole. Both compounds have a fragment at m/z 163 in the MS which corresponds to the loss of Br from the parent molecule. The base peak for the two components, however, differs; the base peak for the major component is m/z 135 (Figure 3b) while the base peak for the secondary product is m/z 149 (Figure 3c). These peaks are likely the result of fragmentation of the carbon-carbon bond alpha to the bromine atom, with the m/z 135 arising from 2-bromosafrole and the m/z 149 arising from 3-bromosafrole (Scheme 3). The presence of these two regiosiомерic bromo products is reasonable based on the mechanism of

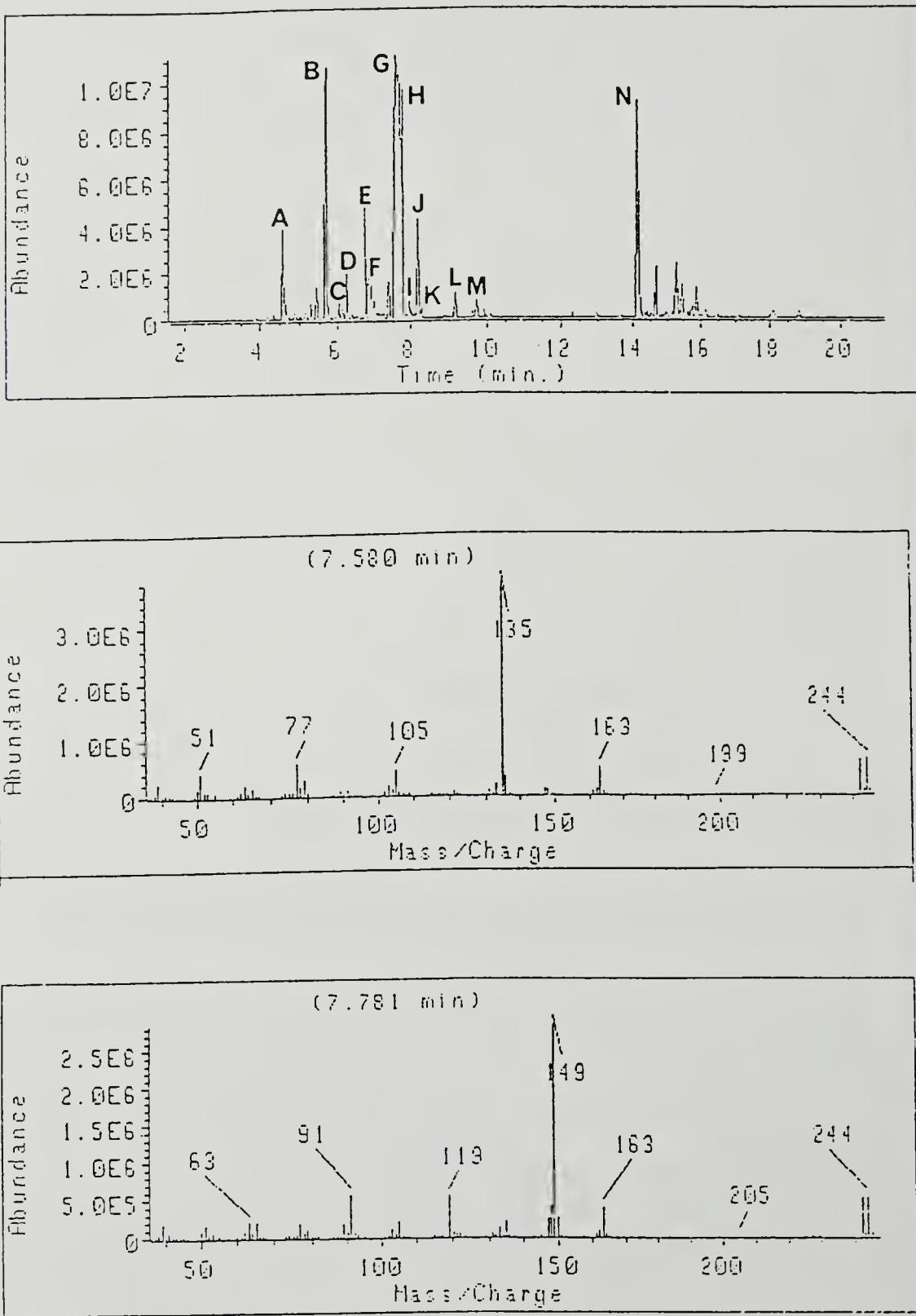
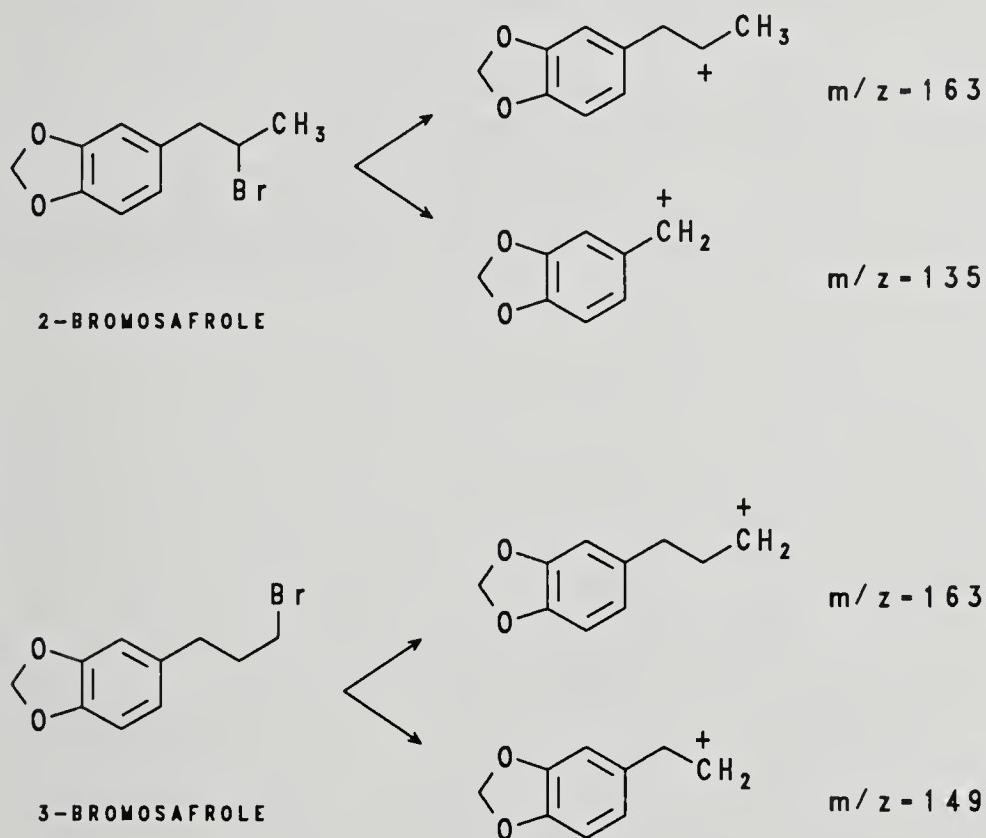


Figure 3. GC-MS analysis of sassafras oil distillate after treatment with 48% HBr.

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the HBr addition reaction (18). Such electrophilic additions are initiated by protonation of the double bond to yield either a primary or secondary carbocation (Scheme 2). Of these, the secondary carbocation forms preferentially due to greater hyperconjugative stabilization. Since the 2-bromosafrole product would form by bromination of the secondary carbocation, it would be expected to form in higher proportion than the 3-bromosafrole product which results from bromine addition to the primary carbocation intermediate. Such a hypothesis accounts for the formation of both bromo regioisomers, with the 2-bromo isomer predominating.



Scheme 3. MS fragmentation of the regioisomeric bromosafroles

The peaks at 8.181 (J) and 8.291 (K) in the chromatogram shown in Figure 3a have a similar MS fragmentation pattern as was observed for Peaks G and H. Both J and K have a molecular weight of 258 and contain one bromine atom. The base peaks at 151 for J and 165 for K differ by 14 mass units (a methylene group), with the lower mass base peak being the compound present in higher concentration based on relative peak heights. These data are consistent with HBr addition to the isolated double bond in 4-allyl-1,2-dimethoxybenzene. The major addition product of this pair is the 2-bromo derivative and it fragments to yield the lower mass peak at m/z 151. The minor product of this pair fragments to yield the m/z 165 ion. Thus, both the 2-bromo- and 3-bromo-products from the HBr addition to 4-allyl-1, 2-

dimethoxybenzene were observed in the sample. The peak in Figure 3 at 9.168 minutes (peak L) corresponds to the bromination of the trimethoxy-substituted allylbenzene at the 2-position in the side chain. This assignment is substantiated by the presence of a molecular ion at m/z 288 and a peak at m/z 209 resulting from the loss of bromine. The base peak in this spectrum at m/z 181 is from the loss of CH_3CHBr^+ to yield the trimethoxybenzyl fragment, demonstrating that bromination occurred at the 2-position.

The brominated sassafras oil was treated with methylamine in an attempt to show that N-methyl-1-(3,4-methylenedioxyphenyl)-2-propanamine (3,4-methylenedioxymethamphetamine, MDMA) could be synthesized by this method. The chromatogram in Figure 4a was obtained following isolation of the basic fraction from the reaction mixture. The major component in the chromatogram has a retention time of 7.350 minutes and its mass spectrum (Figure 4b) shows a molecular ion at 193 and a base peak at m/z 58. These data are consistent with the profile for

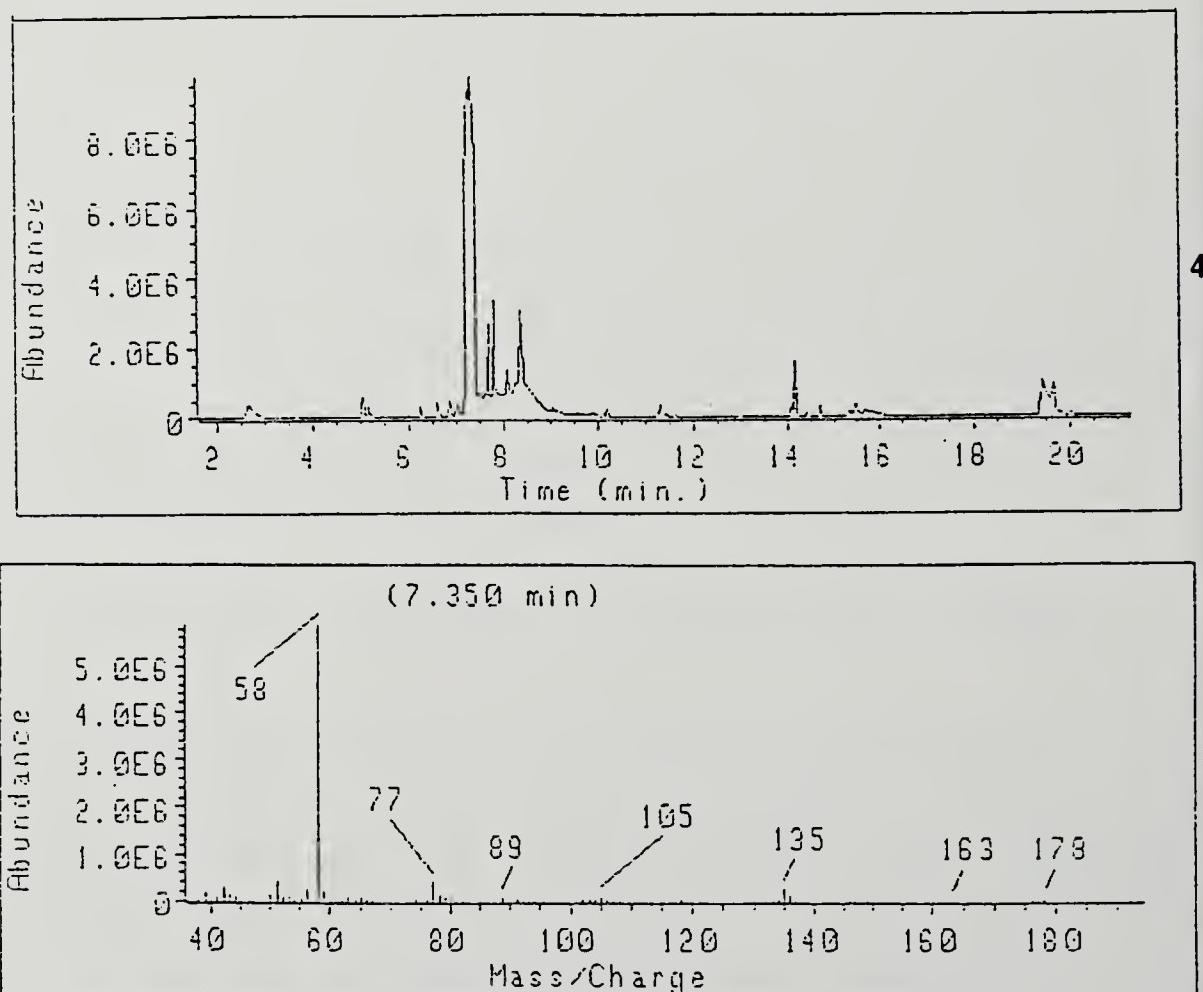
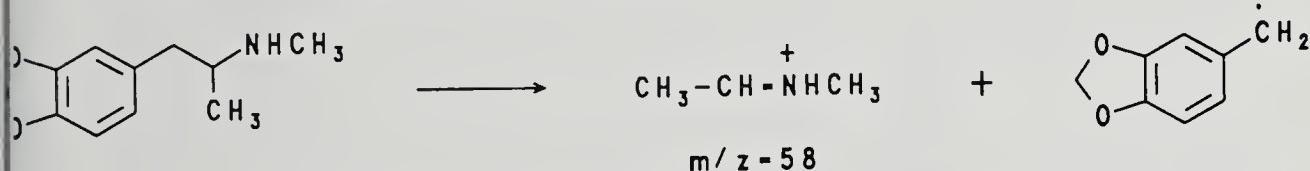


Figure 4. GC-MS analysis of the basic fraction isolated following methylamine treatment of the brominated sassafras oil.

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MDMA under identical analysis conditions. The base peak at m/z 58 in the mass spectrum is the result of amine-dominated fragmentation to yield the imine species and the 3,4-methylenedioxybenzyl radical (Scheme 4). Thus, this synthetic procedure can be used to prepare MDMA in significant quantities from the constituents of an uncontrolled plant material native to the US.



Scheme 4. MS fragmentation of MDMA

Characterization/Analysis of MDA and MDA Derivatives

MDA derivatives are easily identified by their characteristic mass spectra and can be separated by reversed-phase liquid chromatography (RPLC). RPLC is very effective for the resolution of homologues since molecular hydrophobic surface area is a major factor in the chromatographic retention process. The chromatogram in Figure 5 shows the separation of a series of N-alkyl MDA derivatives under reversed-phase HPLC conditions. The stationary phase is composed of n-octadecyl-silica (a C₁₈ hydrocarbon covalently linked to silica) and the mobile phase is acidified methanol-water containing triethylamine as the silanol masking agent. Thus the basic N-alkyl MDA derivatives are chromatographed as the more hydrophilic protonated amine species. These compounds elute in order of increasing hydrophobic surface area roughly equivalent to the hydrocarbon content of the N-substituent. Thus, unsubstituted MDA elutes before N-methyl MDA (MDMA), followed by the derivatives with two-carbon N-substituents (peaks 3 and 4), the three-carbon N-substituents (peaks 5 and 6), with the N-OHMDA eluting last in this system.

Figure 5 illustrates the effect on resolution obtained by the addition of the masking agent triethylamine (1% total volume) to the mobile phase. Initial separations of N-OHMDA from MDA and other N-alkyl substituted analogues were attempted using a C₁₈ stationary phase with a mobile phase consisting of pH 3.0 phosphate buffer:acetonitrile mixtures. The results of this initial chromatograph were poor peak shape and inadequate resolution due to the extensive tailing of the amines. This phenomenon is caused by solute interactions with the unreacted silanol sites on the silica-based stationary phase. The silica surface remains weakly acidic and is, therefore, capable of producing interactions between the solute and stationary phase other than the hydrophobic interaction between the non-polar moieties of the solute and the stationary phase. Protonated amines are capable of undergoing both ion exchange and hydrogen bonding interactions with the exposed silanol sites. The degree of contribution from each of these possible interactions, hydrophobic, ion

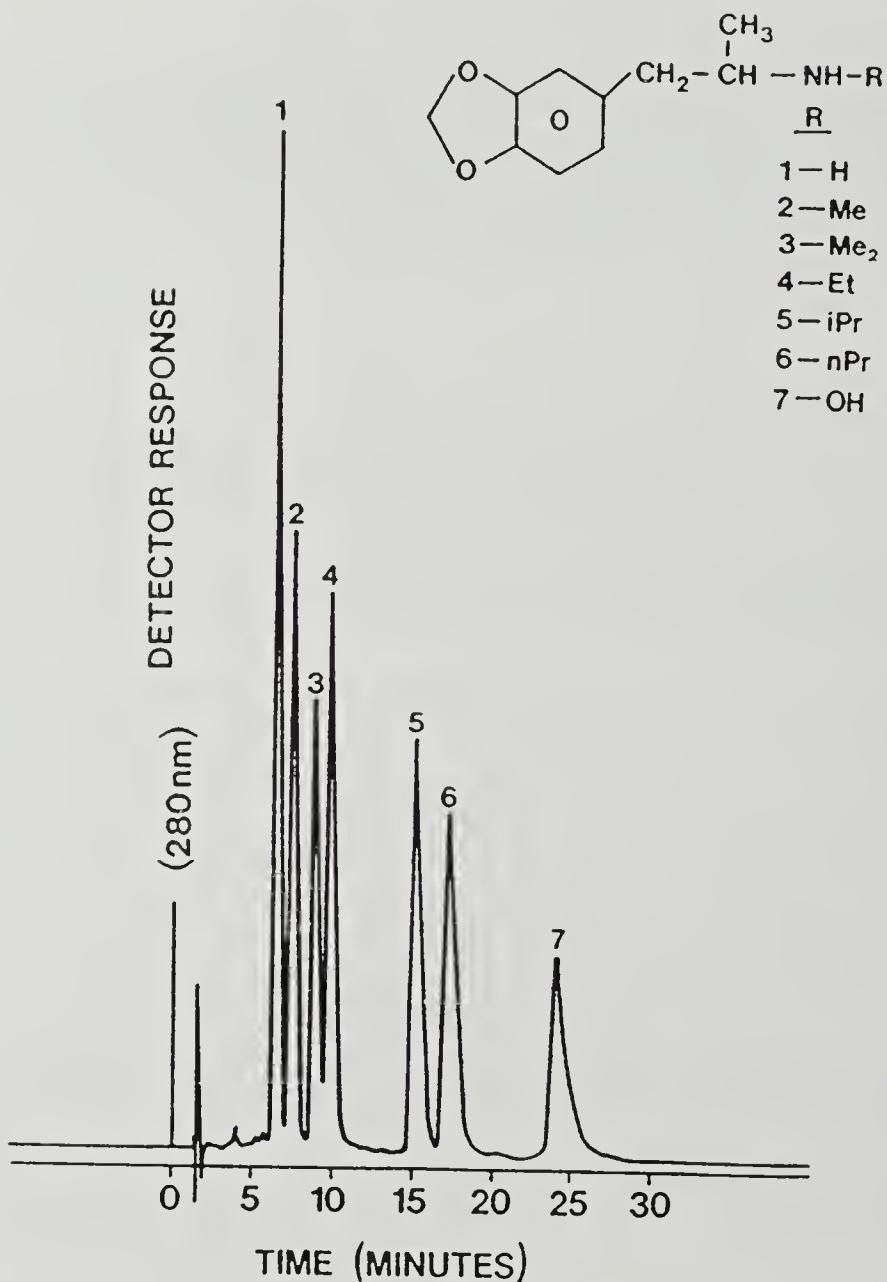


Figure 5. Reversed phase liquid chromatographic separation of MDA and N-substituted derivatives.

exchange and hydrogen bonding, dictates the chromatographic results and can lead to severe peak tailing or even irreversible adsorption of the solute to the stationary phase. This problem can be remedied by the addition of silanol masking agents to the mobile phase. These agents act by blocking the available ion exchange and hydrogen bonding sites of the stationary phase.

Initial chromatographic separation of N-OHMDA from other N-alkyl MDA derivatives in this study showed N-OHMDA to consistently display increased retention over MDA, MDMA and MDEA. Based on the findings described above

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concerning the increase in reversed phase retention with hydrophobic surface area of the N-substituent of the MDA derivatives, it would be reasonable to expect that N-OHMDA should elute first. Furthermore, the relative retention of N-OHMDA compared to the N-alkyl derivatives was observed to increase with increasing pH. For example, a change in mobile phase pH from 2.5 to 5.5 produced an approximate 1.2-fold increase in retention for MDMA, while the same pH change produced about a 2.5-fold increase in the retention of N-OHMDA. One potential explanation for this variation in retention properties as a function of N-substituent is a difference in basicity produced by the N-hydroxyl group. In titration experiments to measure the relative basicity, MDA was found to have a pKa of 10.04 while N-OHMDA had a pKa of 6.22. These measurements were made by titrating aqueous solutions of the hydrochlorides of MDA and N-OHMDA with standardized sodium hydroxide solutions. The significant difference in basicity between N-OHMDA and the N-alkyl MDA derivatives may account for the reversed-phase retention differences between these compounds. Variation of the mobile phase pH in the 2.5 to 5.5 range would result in a significant change in the degree of ionization of a relatively weak base such as N-OHMDA (pKa 6.22), while having little effect on the more basic amines such as MDA (pKa 10.04) and the N-alkyl derivatives.

The aqueous solution stability of N-OHMDA was also studied in anticipation of the need for animal dosing for biological studies. Earlier studies in our laboratory demonstrated the thermal instability of N-OHMDA and the inability of this compound to survive injection port temperatures in many gas chromatographic procedures. The GC-MS analysis of N-OHMDA produced two compounds, MDA and the oxime of 3,4-methylenedioxypyphenylacetone likely from an oxidation/reduction disproportionation reaction. Furthermore, preliminary liquid chromatographic studies showed a decrease in N-OHMDA peak size and the appearance of a late eluting second peak in solutions of N-OHMDA used over a several day period. The aqueous solution stability of N-OHMDA was studied by varying solution pH from 4 to 10. At pH levels below 7.0, solutions of N-OHMDA were found to be relatively stable, with little change in concentration over a several day period. However the degradation rate was found to increase with an increase in solution pH. At pH 7.0 the degradation half-life ($t_{1/2}$ deg.) was 49.8 ± 2.4 hours, while at pH 10.0 the degradation half-life was 2.57 ± 0.13 hours with rapid conversion to the corresponding oxime (Scheme 5). At a pH greater than 10, decomposition was extremely rapid and consistent estimates of the rate constants were difficult to obtain. The results of this study show that aqueous solutions of N-OHMDA maintained in the pH 7.0 range can be expected to deliver the parent drug for biodisposition experiments.



Scheme 5. Decomposition of N-OHMDA to the oxime

In some preliminary studies in rats dosed intravenously (iv) with N-OHMDA via a jugular vein cannula, drug levels appear to decrease rapidly. Furthermore, the corresponding oxime was not detected in any serum samples drawn during the 24 hour period following dosing. The major metabolite observed in the serum samples was MDA which appears rapidly following dosing and becomes the major sample component within 20 to 30 minutes after dosing. Drug levels were determined for these studies using a reversed phase HPLC procedure following solvent extraction of the serum samples. The biodistribution, stability and analytical properties of this unique compound (N-OHMDA) as well as other designer analogues of MDMA remain the focus of our work.

REFERENCES

1. Noggle, F. T., Jr.; DeRuiter, J.; Coker, S. T.; Clark, C. R. *J. Assoc. Anal. Chem.* 1987, 70, 981.
2. Noggle F. T., Jr.; DeRuiter, J.; McMillian, C. L.; Clark, C. R. *J. Liq. Chromatogr.* 1987, 10, 2497.
3. Noggle, F. T., Jr.; Clark, C. R.; Valaer, A. K.; DeRuiter, J. *J. Chromatogr. Sci.* 1988, 26, 410.
4. Shulgin, A. T.; Nichols, D. E. "The Psychopharmacology of Hallucinogens", Stillman, R. C.; Willette, R. E.; Eds.; Permagon Press, New York, 1987, 74.
5. Shulgin, A. T. *J. Psychedelic Drugs*, 1986 18, 291.
6. Johnson, M. P.; Hoffman A. J. and Nichols, D. E. *Eur. J. Pharmacol.*, 1986, 132, 269.
7. Kalix, P. A. *Arzneim. Forsch.*, 1986, 30, 1019.
8. Nichols, D. E.; Lloyd, D. H.; Hoffman, A. J.; Nichols, M. B. and Yim, G. K. W. *J. Med. Chem.*, 1982, 25, 530.
9. Commins, D. L.; Vosmer, V.; Virus, R. M.; Woolverton, C. R.; Schuster, C. R. and Seiden, L. S. *J. Pharmacol. Exp. Ther.* 1987, 241, 338.
10. O'Hearn, E.; Battaglia, G.; De Souza, E. B.; Kuhar, K. J. and Molliver, M. E. *Soc. Neurosci. Abstr.*, 1986, 12, 336.2
11. De Souza, E. B.; Battaglia, G.; Shu, Y. Y.; and Kuhar, M. J. *Amer. Coll. Neuropsychopharm.*, 1986, 207.

Derivatives of "Ecstasy" (MDMA)

12. Kulmala, H. K.; Boja, J. W. and Schechter, M. D. *Life Sciences*, 1987, **41**, 1425 and Frith, C. H.; Chang, L. W.; Lattin, D. L.; Walls, R. C.; Hamm, J. and Doblin, R. *Fund., Appl. Tox.*, 1987, **9**, 110, and Project Report, Toxicology Pathology Associates, Little Rock, Ark., 1986.
13. Frith, C. H. "Project Report, Toxicology Pathology Associates", Little Rock, Ark., 1986.
14. Braun, U.; Shulgin, A. T.; Braun, G. *J. Pharm. Sci.* 1980, **69**, 192.
15. Dal Cason, T. A. *J. Forensic Sci.* 1990, **35**, 675.
16. Tyler, V. E.; Brady, L. R.; Robbers, J. E. "Pharmacognosy", 7th ed., Lea and Febiger, Philadelphia 1976, 165.
17. Reynolds, J. E. F. "Martindale The Extra Pharmacopoeia", 28th ed., The Pharmaceutical Press, London 1982, 683.
18. March, J. "Advanced Organic Chemistry", 2nd ed., McGraw-Hill Book Company, New York 1977, 687.

CLANDESTINE SYNTHESIS OF METHAMPHETAMINE DERIVATIVES¹

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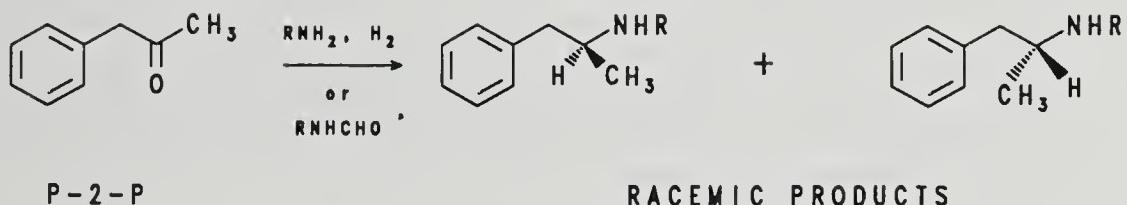
INTRODUCTION

Amphetamine and methamphetamine continue to be two of the more frequently encountered illicit drugs produced in clandestine laboratories (1-2). The major methods (1-4) by which these amines are prepared in clandestine laboratories are outlined in Scheme 1 and include: 1). amination of phenyl-2-propanone (P-2-P) under reducing conditions (Method A) and 2). hydrogenolysis of 1-hydroxy- or 1-chloro-1-phenyl-2-propanamines (Method B). Since the amination method (Method A) employs a carbon-nitrogen bond formation reaction with an achiral precursor (P-2-P), the amphetamine or methamphetamine products are formed as racemates - equimolar amounts of the more potent S-enantiomer and the R-enantiomer. Also, as a result of U.S. Federal control of P-2-P, the essential precursor for the amination method, the clandestine chemist frequently must first prepare this intermediate. This is commonly done by base-catalyzed condensation of phenylacetic acid and acetic anhydride. However, this condensation reaction also results in the formation of a second ketone, dibenzylketone (1, 3-diphenyl-2-propanone) in variable quantities (Scheme 2) (2). Since the P-2-P prepared by this route is rarely purified, reductive amination with the crude condensation product yields a mixture of racemic amphetamine or methamphetamine and alphabenzylphenethylamine or alpha-benzyl-N-methylphenethylamine (Scheme 2) (2).

The hydrogenolysis method (Method B) uses starting materials that contain the structural elements of amphetamine or methamphetamine in chiral form (3,4). For example, the norephedrines and norpseudoephedrines contain the structural skeleton of amphetamine, while the ephedrines and pseudoephedrines possess the

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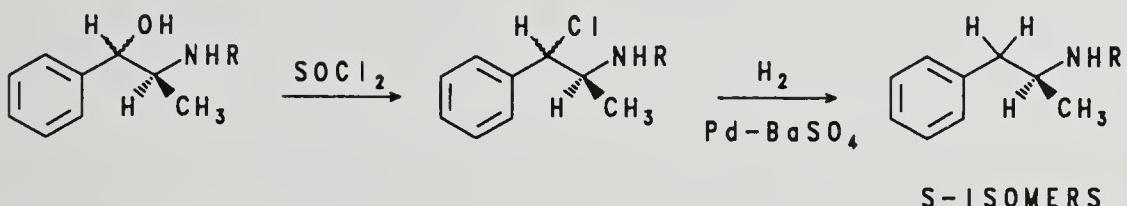
METHOD A



P - 2 - P

RACEMIC PRODUCTS

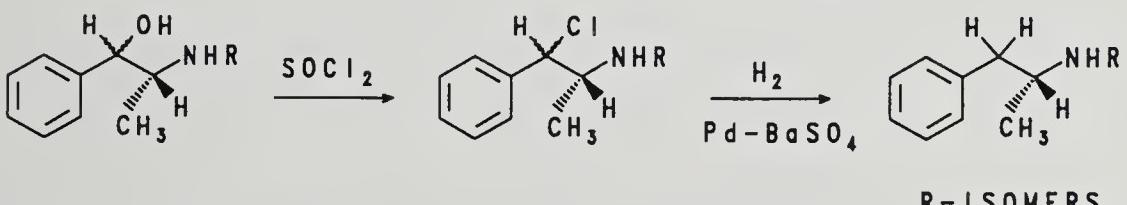
METHOD B



R,S- or *S,S-*

STARTING MATERIALS

S-ISOMERS



R,R- or *S,R-*

STARTING MATERIALS

R-ISOMERS

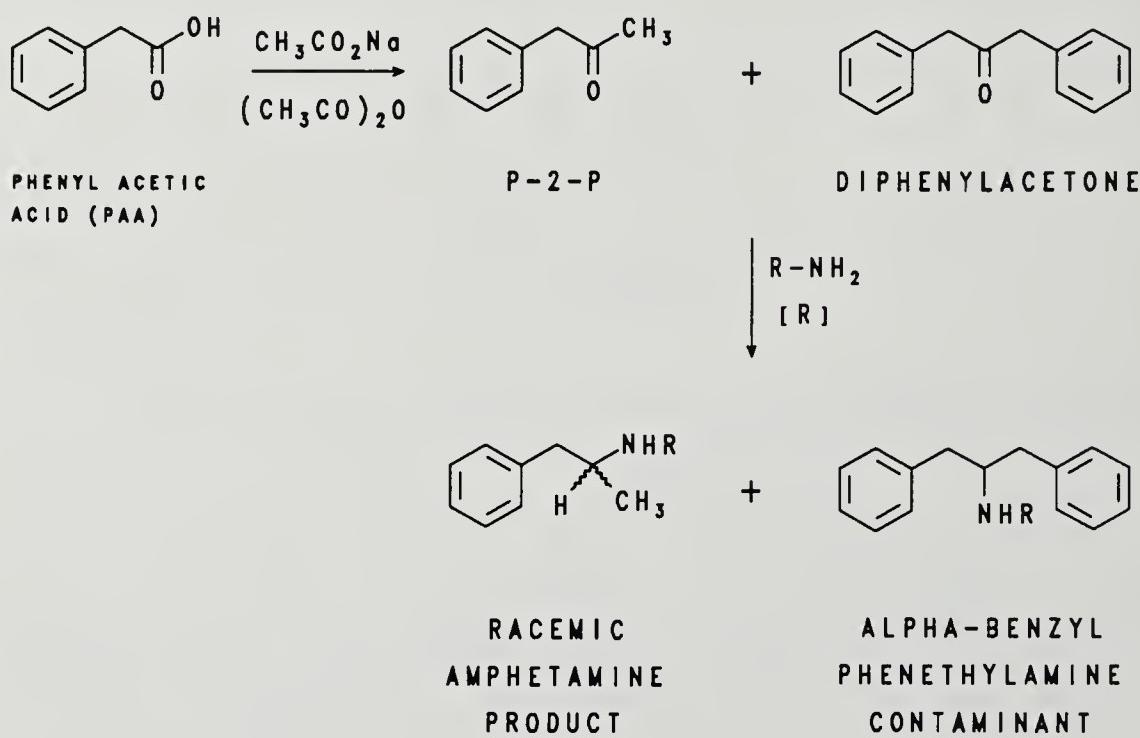
Scheme 1. Methods for the synthesis of amphetamine and methamphetamine

basic structural elements of methamphetamine (Table 1). Direct hydrogenolysis of these compounds or the 1-chloro intermediates yields the amphetamine or methamphetamine products in enantiomerically pure form. For example, by this method *R,S*-ephedrine is converted exclusively to the more active *S*-enantiomer of methamphetamine.

Which of these synthetic methods is employed in the production of an illicit amphetamine or methamphetamine sample can be determined by complete analysis of the composition and stereochemistry of the components in the drug sample. The

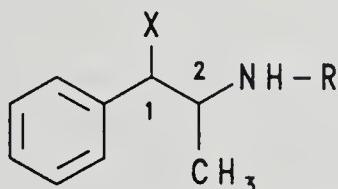
Clandestine Synthesis of Methamphetamine Derivatives

complete characterization of a clandestine drug product may be important because, in addition to the method of preparation, it allows for: 1). the identification of drug samples of common origin, 2). differentiation of legitimate pharmaceutical products from illicitly manufactured products, and 3). the identification of potentially toxic contaminants or reaction side products. In this paper we report the results of studies using high performance liquid chromatographic (HPLC) methods to analyze and determine the composition of methamphetamine and amphetamine samples prepared by clandestine laboratory operators.



Scheme 2. Synthesis of amphetamine and methamphetamine from phenylacetic acid

Structure and Stereochemistry of Common
Amines in Forensic Samples



X	R	Configuration	Name
OH	H	1R, 2S	(-) -Norephedrine
OH	H	1S, 2R	(+) -Norephedrine
OH	H	1R, 2R	(-) -Norpseudoephedrine
OH	H	1S, 2S	(+) -Norpseudoephedrine
OH	CH ₃	1R, 2S	(-) -Ephedrine
OH	CH ₃	1S, 2R	(+) -Ephedrine
OH	CH ₃	1R, 2R	(-) -Pseudoephedrine
OH	CH ₃	1S, 2S	(+) -Pseudoephedrine
H	H	2S	(+) -Amphetamine
H	H	2R	(-) -Amphetamine
H	CH ₃	2R	(+) -Methamphetamine
H	CH ₃	2R	(+) -Methamphetamine

EXPERIMENTAL

Reagents and Chemicals. Samples of S,R-norephedrine, racemic norephedrine and R,R-norpseudoephedrine were obtained from Aldrich Chemical Company (Milwaukee, WI). Samples of S,R- and R,S-ephedrine and S,S- and R,R-pseudoephedrine and standard samples of amphetamine and methamphetamine were obtained from Sigma Chemical Co. (St. Louis, MO). 2,3,4,6-Tetra-O-acetyl-beta-D-glucopyranosyl isothiocyanate (GITC) was purchased from Polysciences (Warrington, PA). HPLC-grade chloroform and methanol were obtained from J. T. Baker

Clandestine Synthesis of Methamphetamine Derivatives

Chemical Co. (Philipsburg, NJ). Phenylisothiocyanate and HPLC-grade tetrahydrofuran (THF), hexane and acetonitrile were purchased from Fisher Scientific Co. (Fair Lawn, NJ). All other chemicals were reagent grade and were used without further purification.

Instrumentation. The liquid chromatograph consisted of a Waters (Milford, MA) Model 6000A pump, U6K injector, 440 UV detector with dual wavelength accessory operated at 254 nm and 280 nm, and a Houston Instruments (Austin, TX) OmniScribe recorder. Infrared spectra were recorded on a Perkin-Elmer 1500 Fourier transform infrared (FTIR) spectrophotometer. Proton nuclear magnetic resonance (¹H-NMR) spectra were recorded using a Varian T-60A spectrometer (Varian Instruments, Palo Alto, CA).

Chromatographic procedures. Reversed-phase separations were carried out on a 30-cm X 3.9-mm i.d. uBondapak C₁₈ column (Waters) at ambient temperature. The analytical column was preceded by a 7-cm X 2.1-mm i.d. guard column dry packed with Co:Pell ODS (Whatman Inc., Clifton, NJ). The mobile phases consisted of methanol:water:acetic acid (50:49:1) (solvent system 1), methanol:water:acetic acid (60:39:1) (solvent system 2) and tetrahydrofuran:water:acetic acid (35:70:1) (solvent system 3). The mobile phase flow rate was 1.5 mL/min and the detector was operated at 0.2 AUFS.

Derivatization procedures. For the phenylisocyanate (PIT) derivatives, samples of the amines (3 mg) were dissolved in 30 mL of 0.45 N NaOH and extracted as the bases into 30 mL of chloroform. To the chloroform was added 10 uL of neat PIT. The chloroform reaction mixture was then evaporated to dryness under a stream of air. The resulting residue was dissolved in 1 mL of methanol and 5 uL was injected into the liquid chromatograph.

For the GITC derivatives, a sample of each amine (2 mg) was dissolved in 0.45 N NaOH and extracted as the base into 30 mL of chloroform. A 10% molar excess of GITC was then added to the chloroform extract and the derivatization reaction allowed to proceed at room temperature for 10 min. The reaction mixture was then evaporated to dryness under a stream of air. The resulting residue was dissolved in 1 mL of THF or methanol and 5 uL was injected into the liquid chromatograph.

General method for the preparation of the 1-phenyl-1-chloro-2-aminopropanes. A solution of the norephedrine, norpseudoephedrine, ephedrine or pseudoephedrine (10 mmol) and thionyl chloride (10 mL) in chloroform (200 mL) was stirred at reflux for 3 h. The reaction mixture was then cooled to room temperature and the solvent volume reduced to approximately 50 mL under reduced pressure. Addition of anhydrous ether (ca. 200 mL), followed by cooling (0-5°C) resulted in crystallization of the 1-phenyl-1-chloro-2-aminopropane hydrochlorides.

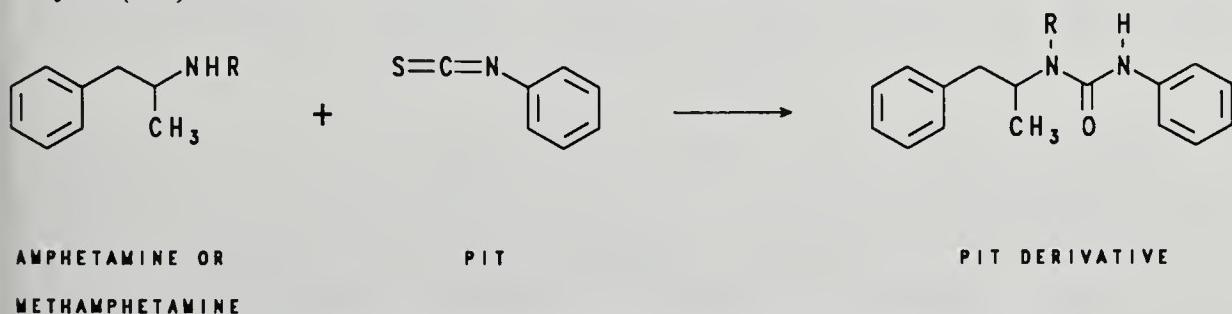
General method for the preparation of the amphetamines and methamphetamines. A mixture of the 1-phenyl-1-chloro-2-aminopropane hydrochloride (2.3 mmol), sodium

acetate trihydrate (1.22 g, 8.9 mmol) and 5% Pd-BaSO₄ (250 mg) in glacial acetic acid was shaken under a hydrogen atmosphere (initial psi of 40-45) on a Parr apparatus for 30-60 min. After the uptake of hydrogen ceased, the catalyst was removed by filtration and washed with water. The combined filtrate and water washings were evaporated to dryness under reduced pressure, and the remaining oil dissolved in water (50 mL) and acidified (pH 1) with conc HCl. The acidic aqueous solution was washed with chloroform (2 X 50 mL), then made basic (pH 12) with 10% NaOH. The basic aqueous suspension was extracted with chloroform (3 X 75 mL), and the combined chloroform extracts washed with water (100 mL) and dried over MgSO₄. Evaporation of the chloroform under reduced pressure yielded the products in free base form. The bases were converted to their hydrochloride salts by treatment with ethereal HCl, and the HCl salts recrystallized from solvent mixtures of absolute ethanol-anhydrous ether.

RESULTS AND DISCUSSION

Determination of the Composition of Clandestine Methamphetamine Samples:

High performance liquid chromatography (HPLC) has proven to be an effective method for the separation and detection of a variety of pharmaceutical preparations and biological samples. HPLC is a non-destructive technique which allows the analyst to recover the sample following analysis and perform other tests of identification and confirmation such as thin layer chromatography (TLC), infrared spectroscopy (IR), ultraviolet spectroscopy (UV), gas chromatography (GC) and mass spectrometry (MS). Yet amines such as amphetamine and methamphetamine are not ideal substances for direct HPLC analysis for several reasons: 1). they have low molar absorptivities in the UV region and thus are not detected with great sensitivity by the UV methods commonly employed, and 2). they exhibit poor chromatographic properties (retentions, peak shape, etc.). Thus derivatization procedures prior to HPLC analysis are often used to enhance the UV absorbance and chromatographic properties of these amines (5-7). For example, derivatization prior to analysis (precolumn) with phenylisothiocyanate (PIT) as shown in Scheme 3 results in the formation of thioureas with good UV absorbance and HPLC retention characteristics. These derivatives also are easy to prepare and are stable to the conditions of HPLC analysis (1-2).



Scheme 3. Phenylisothiocyanate (PIT) derivatization reaction

Clandestine Synthesis of Metamphetamine Derivatives

The initial objective of this work was to develop an HPLC screening method to separate and characterize amphetamine and methamphetamine, as well as the alpha-benzylphenethylamines contaminants that may be present when the amination method is used for clandestine synthesis. This first required the preparation of alpha-benzylphenethylamine standards which are obtained by reaction of commercially available 1,3-diphenyl-2-propanone with ammonium acetate or methylamine to form the imine, and reduction of the imines with sodium borohydride (Scheme 4). The structures and purity of these standards are determined by common spectroscopic and



1,3-DIPHENYL-2-PROPANONE

BENZYLPHENETHYLAMINES

Scheme 4. Synthesis of alpha-benzylphenethylamines

chromatographic methods. Samples of racemic amphetamine, racemic methamphetamine and the alpha-benzylphenethylamine standards were then converted to PIT derivatives to facilitate HPLC analysis. All four compounds are resolved (Figure 1) using a reversed phase system with a C_{18} stationary phase and a mobile phase of acetonitrile-water-acetic acid (50:49:1). In this system the primary amine amphetamine derivative elutes first, followed closely by the N-methyl secondary amine derivative, methamphetamine. The alpha-benzylphenethylamines have significantly greater hydrophobicities and thus greater retention times than amphetamine or methamphetamine in the reversed phase system. Also, among the alpha-benzylphenethylamines, the N-methyl derivative elutes later than the primary amine.

The utility of this HPLC method for determination of sample composition is illustrated by the analysis of forensic samples. The chromatogram in Figure 2 was obtained from the analysis of a clandestine dosage form known on the street as a "minibennie". By comparing retention times, this sample was found to contain amphetamine and alpha-benzylphenethylamine, suggesting that this sample was prepared by the amination method, and the P-2-P ketone required for synthesis was obtained by the phenylacetic acid condensation reaction. The third compound in this mixture (peak 1) was identified as underivatized caffeine, a diluent added by the clandestine chemist to "cut" the drug and increase quantity.

Figure 3 shows the HPLC analysis of a PIT derivatized sample of a gummy brown powder removed from a baking dish discovered at the scene of a suspected clandestine methamphetamine laboratory. By comparison of relative retention times, this sample was found to contain methamphetamine and alpha-benzyl-N-methylphenethylamine. Again the presence of the alpha-benzyl contaminant strongly suggests that this drug product was prepared by the amination method and that the P-2-P used was prepared from the phenylacetic acid condensation route.

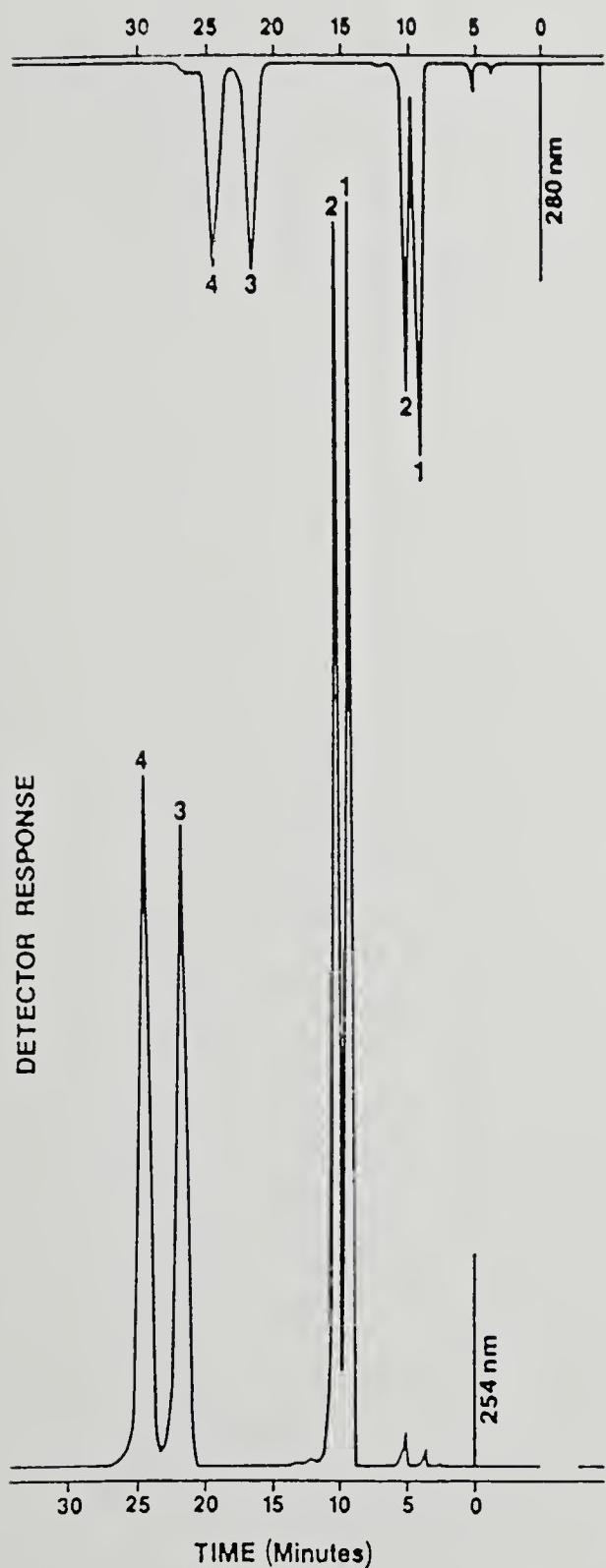


Figure 1. Liquid chromatographic separation of PIT derivatized amines.
Peaks: 1=racemic amphetamine, 2=racemic methamphetamine,
3=alpha-benzylphenethylamine,
4=alpha-benzyl-N-methylphenethylamine. Solvent system 1.

Clandestine Synthesis of Methamphetamine Derivatives

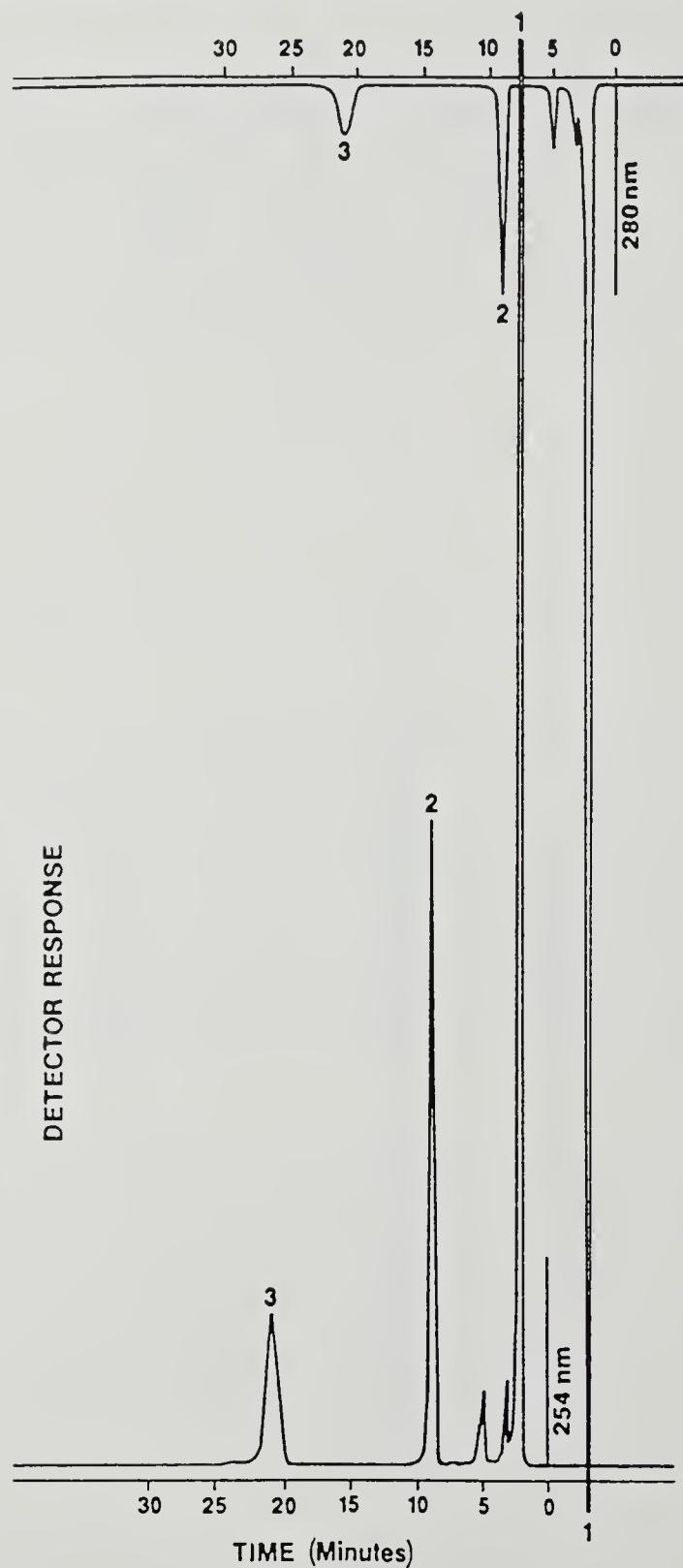


Figure 2. Liquid chromatographic separation of a PIT derivatized "minibennie" sample. Peaks: 1=caffeine (underderivatized, 2=amphetamine, 3=alpha-benzyl-N-methylphenethylamine. Solvent system 1.

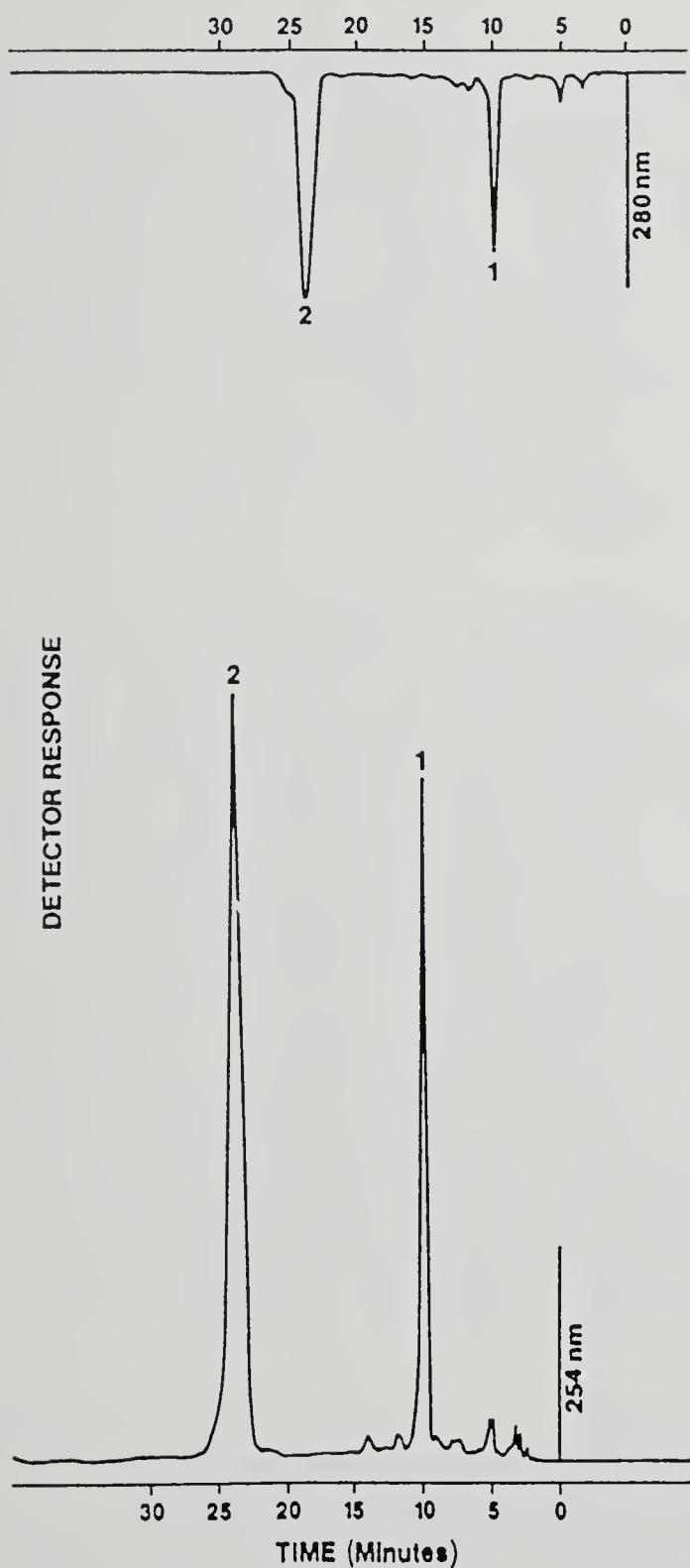


Figure 3. Liquid chromatographic separation of a PIT derivatized powder from a clandestine laboratory. Peaks: 1=methamphetamine, 2=alpha-benzyl-N-methylphenethylamine. Solvent system 1.

Clandestine Synthesis of Methamphetamine Derivatives

The HPLC analysis of PIT derivatives allows for efficient identification of methamphetamine, amphetamine, alpha-benzylphenethylamine contaminants and other diluents. However, this method alone does not necessarily yield all the information available concerning the source of an illicit methamphetamine or amphetamine sample. For example, the only substance detected in the drug sample analyzed in Figure 4 is methamphetamine. While this analysis is useful for identification, it does not provide the level of detail required to determine if the origin of the sample may be pharmaceutical manufacture or clandestine synthesis by either the amination or hydrogenolysis methods. To more accurately predict the source of such an illicit sample, it is necessary to determine the stereochemistry or enantiomeric composition of a methamphetamine or amphetamine sample.

Determination of the Enantiomeric Composition of Clandestine Methamphetamine Samples:

A number of chromatographic methods have been developed for determination of sample stereochemistry and the resolution of enantiomers (3,4). The primary methods include the use of 1). chiral stationary phase, 2). achiral stationary phases with a mobile phase containing a chiral additive, and 3). precolumn derivatization of enantiomers to form diastereomers and analysis in an achiral chromatographic system. The latter derivatization approach was used in these studies. The formation of covalent diastereomers typically involves precolumn derivatization with a homochiral derivatizing agent and numerous such reagents have been developed that contain functional groups capable of reaction with primary and secondary amines such as amphetamine and methamphetamine (8). The diastereomers formed from the reaction of a homochiral derivatizing reagent and a racemic amine can be separated using conventional achiral stationary phases in either normal or reversed phase procedures. The derivatizing agent selected for these studies, 2,3,4,6-tetra-O-acetyl-B-Dglucopyranosyl isothiocyanate (GITC), produces diastereomeric thiourea derivatives upon reaction with racemic amines (Scheme 5). Commercially available GITC is chemically and stereochemically stable and the thiourea derivatives have strong absorption properties in the UV range. Thus this reagent is a convenient means for diastereomeric derivatization of chiral primary and secondary amines (3,4).

As discussed earlier, the enantiomers of norephedrine, and norpseudoephedrine as well as ephedrine and pseudoephedrine contain the structural elements of amphetamine and methamphetamine in chiral form (Table 1). In theory, these compounds can be converted to enantiomerically pure amphetamine and methamphetamine products either directly or via the corresponding 1-chloro intermediates as outlined in Scheme 1 (Method B). To conduct the stereochemistry studies by HPLC, commercially available enantiomers of the norephedrine, norpseudoephedrine, ephedrine and pseudoephedrine starting materials and

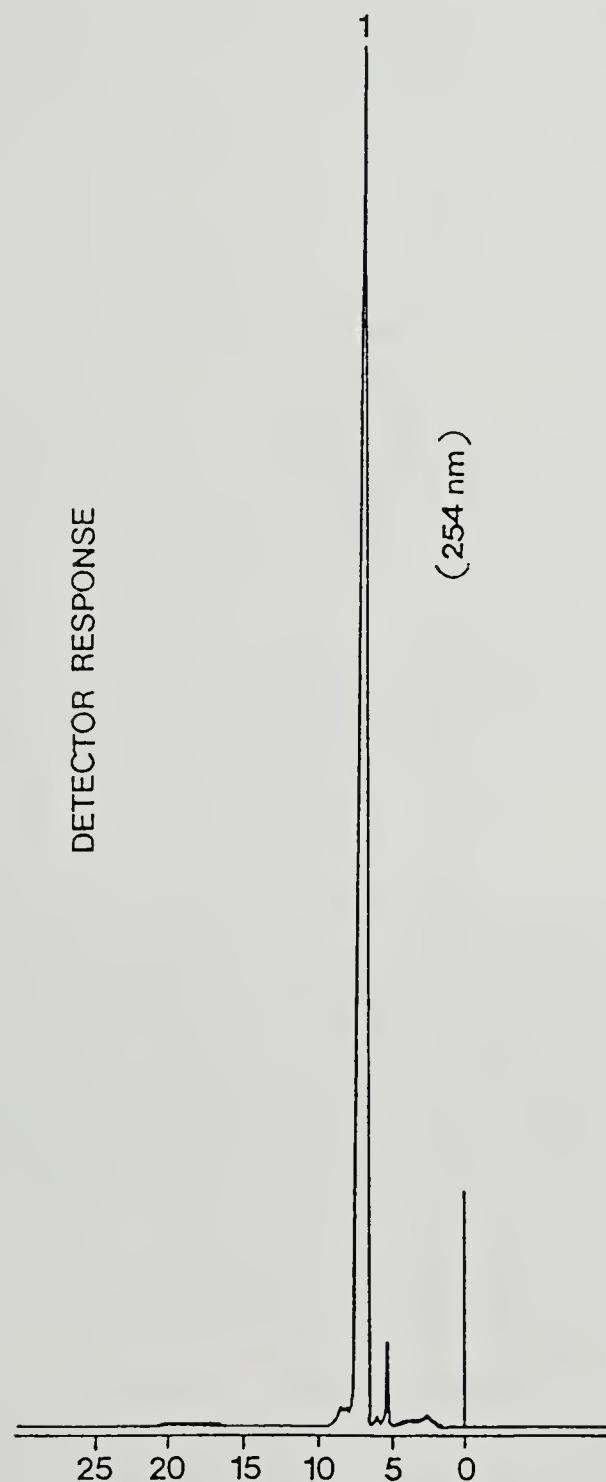
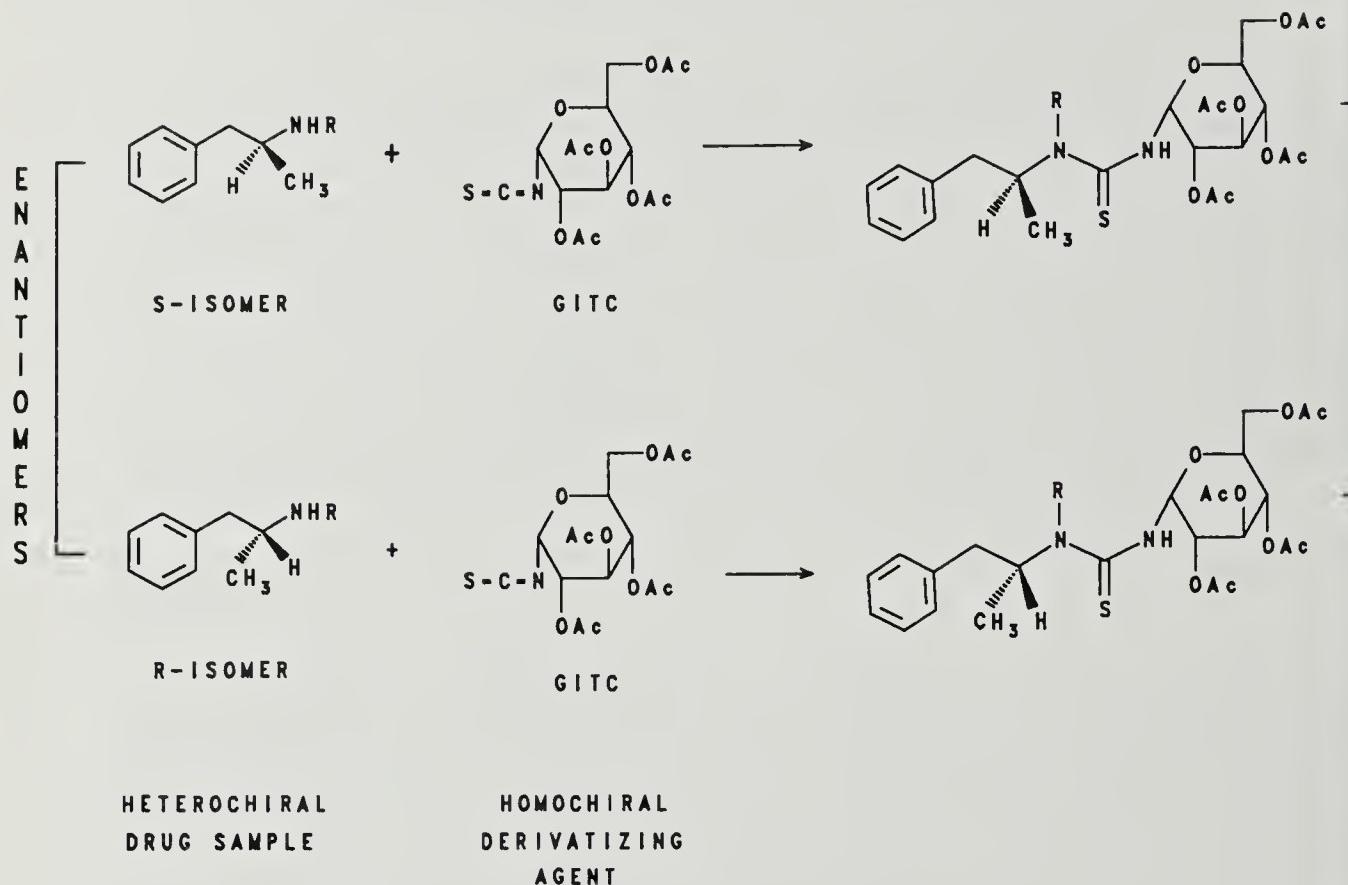


Figure 4. Liquid chromatographic separation of a PIT derivatized powder from a clandestine laboratory: Peak=methamphetamine. Solvent system 1.

Clandestine Synthesis of Methamphetamine Derivatives



Scheme 5. GITC derivatization reaction

amphetamine and methamphetamine products were derivatized using GITC (Scheme 5). Separation of the GITC derivatives was studies using an achiral C₁₈ stationary phase and various aqueous acidic mobile phases. Successful separations are shown in Figures 5 and 6. Figure 5 shows that a solvent system of methanol:water:acetic acid (60:39:1) allowed for efficient separation of the diastereomeric derivatives prepared from the individual enantiomers of the starting materials norephedrine and norpseudoephedrine, as well as the product amphetamines. Similar results are obtained upon analysis of the diastereomers prepared from the enantiomeric secondary amines, ephedrine and pseudoephedrine and the methamphetamine products, using a solvent system of THF:water:acetic acid (35:70:1) (Figure 6).

Initially this HPLC technique was used to demonstrate that absolute configuration remains unaffected when this synthetic method is used, and enantiomerically pure products are obtained (3,4). Thus, each enantiomer of ephedrine (R,S and S,R) and pseudoephedrine (S,S and R,R) was converted to the corresponding 1-chloro intermediate by treatment with thionyl chloride and the 1-chloro intermediates subjected to hydrogenolysis to yield the methamphetamine products (Scheme 1, Method B). The methamphetamine products formed from these reactions were analyzed by HPLC following GITC derivatization, using the standard

analysis described above to interpret the results. These analyses demonstrated that only a single enantiomer of methamphetamine was formed from each chiral starting material and that the configurations of the methamphetamine products were the same as the configurations of the 2-carbon of the chiral starting material. Thus, as predicted by theory, the absolute configuration of chiral starting materials is retained in the methamphetamine products in this synthetic procedure. These results are illustrated by the chromatograms in Figure 7, which show that only S-methamphetamine was formed by R,S-ephedrine and only R-methamphetamine was obtained from S,R-ephedrine. Analogous results also were obtained in the study of this synthetic method using the enantiomers of norephdrine and norpseudoephedrine to prepare the S- and R-enantiomers of amphetamine.

The utility of this HPLC method was demonstrated by the analysis of a variety of forensic samples. Figure 8 shows the chromatogram from a GITC-derivatized sample of methamphetamine collected at the site of a clandestine laboratory. The chromatogram shows that the sample is a mixture of S- and R-methamphetamine, suggesting that it was prepared by a reductive amination procedure. Figure 9 shows the analysis of sample that consists solely of R-methamphetamine. While it is possible that this product was synthesized from S,R-ephedrine or R,R-pseudoephedrine by the hydrogenolysis method, it is more likely that the drug was obtained by extraction of a common inhaler product which is known to contain R-methamphetamine.

HPLC analysis of the clandestine sample in Figure 10 revealed that it consisted of a mixture of R,S-ephedrine, S,R-ephedrine, S-methamphetamine and R-methamphetamine. It is possible that this product was prepared by the hydrogenolysis method, using both R,S-ephedrine and S,R-ephedrine starting materials. Figure 11 is the chromatogram of a forensic sample that contains R,S-ephedrine and racemic methamphetamine (R + S). These stereochemical results clearly indicate that the methamphetamine product was not prepared from the R,S-ephedrine. In this sample the ephedrine appears to have been added as a diluent for the sample.

Clandestine Synthesis of Methamphetamine Derivatives

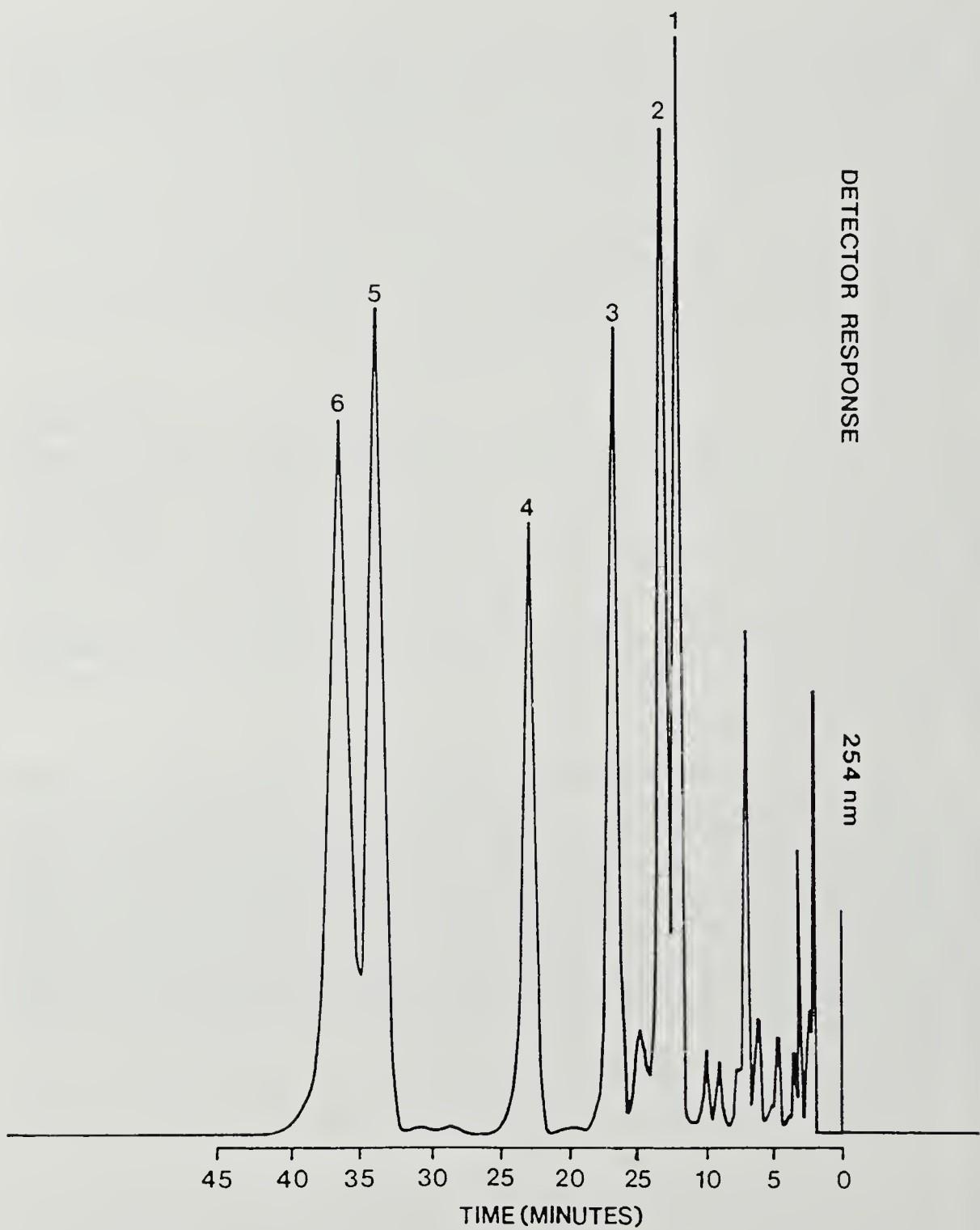


Figure 5. Liquid chromatographic separation of GITC derivatized amines.
Peaks: 1=R,R-norpseudoephedrine, 2=R,S-norephedrine,
3=S,R-norephedrine, 4=R-amphetamine, 5=S-amphetamine.
Solvent system 2.

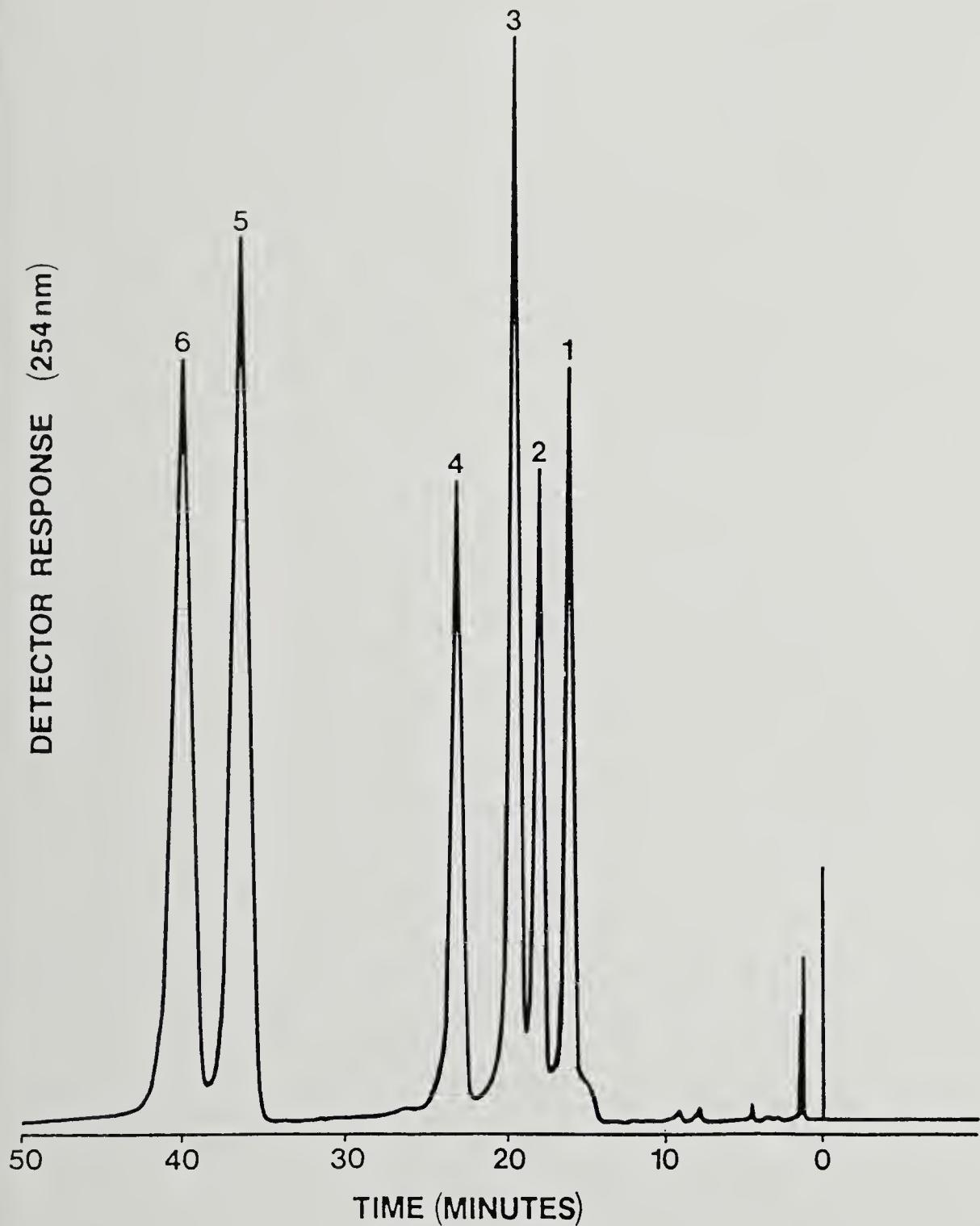


Figure 6. Liquid chromatographic separation of GITC derivatized amines. Peaks: 1=R,R-pseudoephedrine, 2=S,S-pseudoephedrine, 3=R,S-ephedrine, 4=S,R-ephedrine, 5=S-methamphetamine, 6=R-methamphetamine. Solvent system 3.

Clandestine Synthesis of Methamphetamine Derivatives

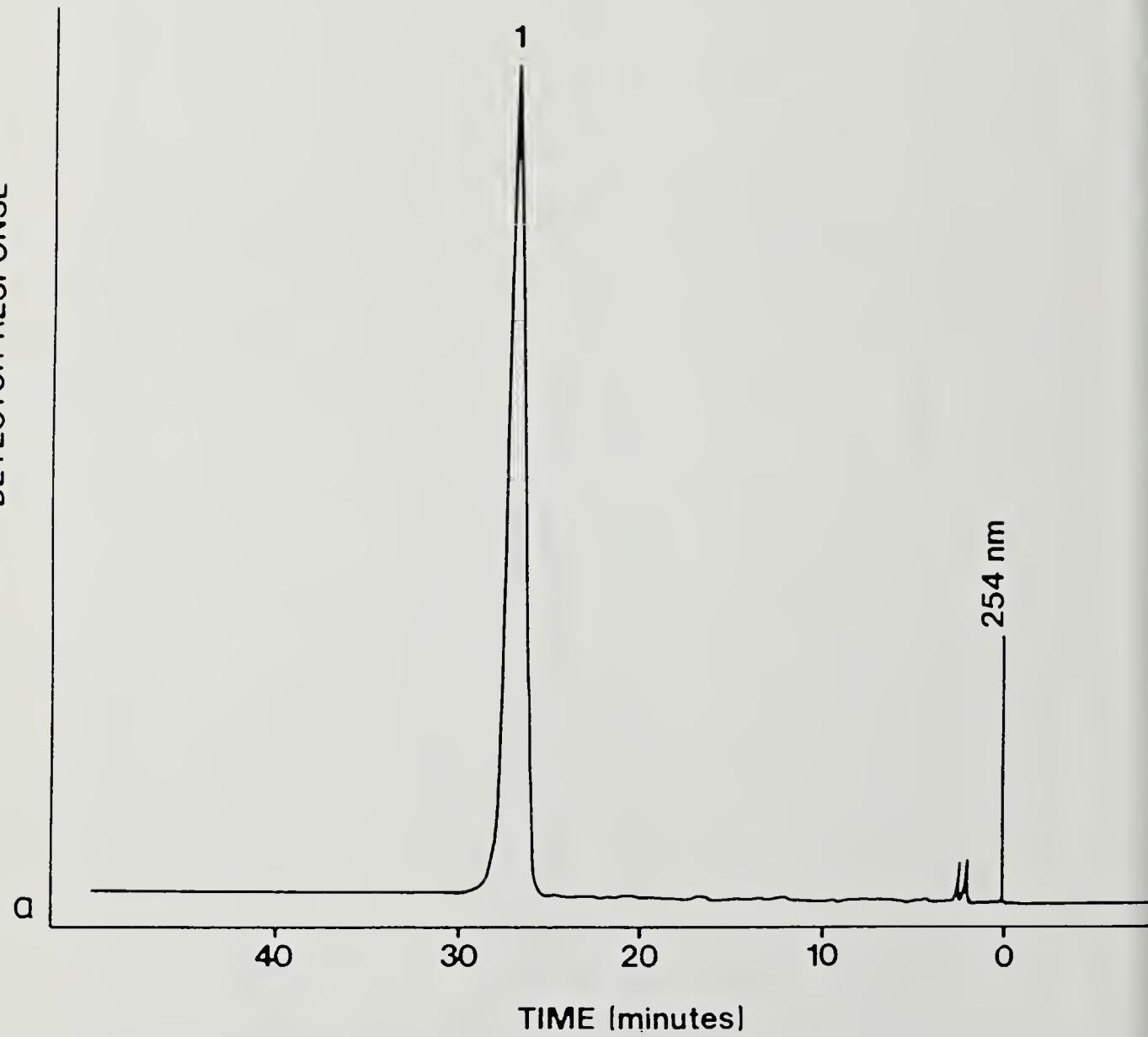


Figure 7A. Liquid chromatographic separation of GITC derivatized methphetamines synthesized from ephedrines. 7A. A= S-methamphetamine synthesized from R,S-ephedrine. Solvent system 3.

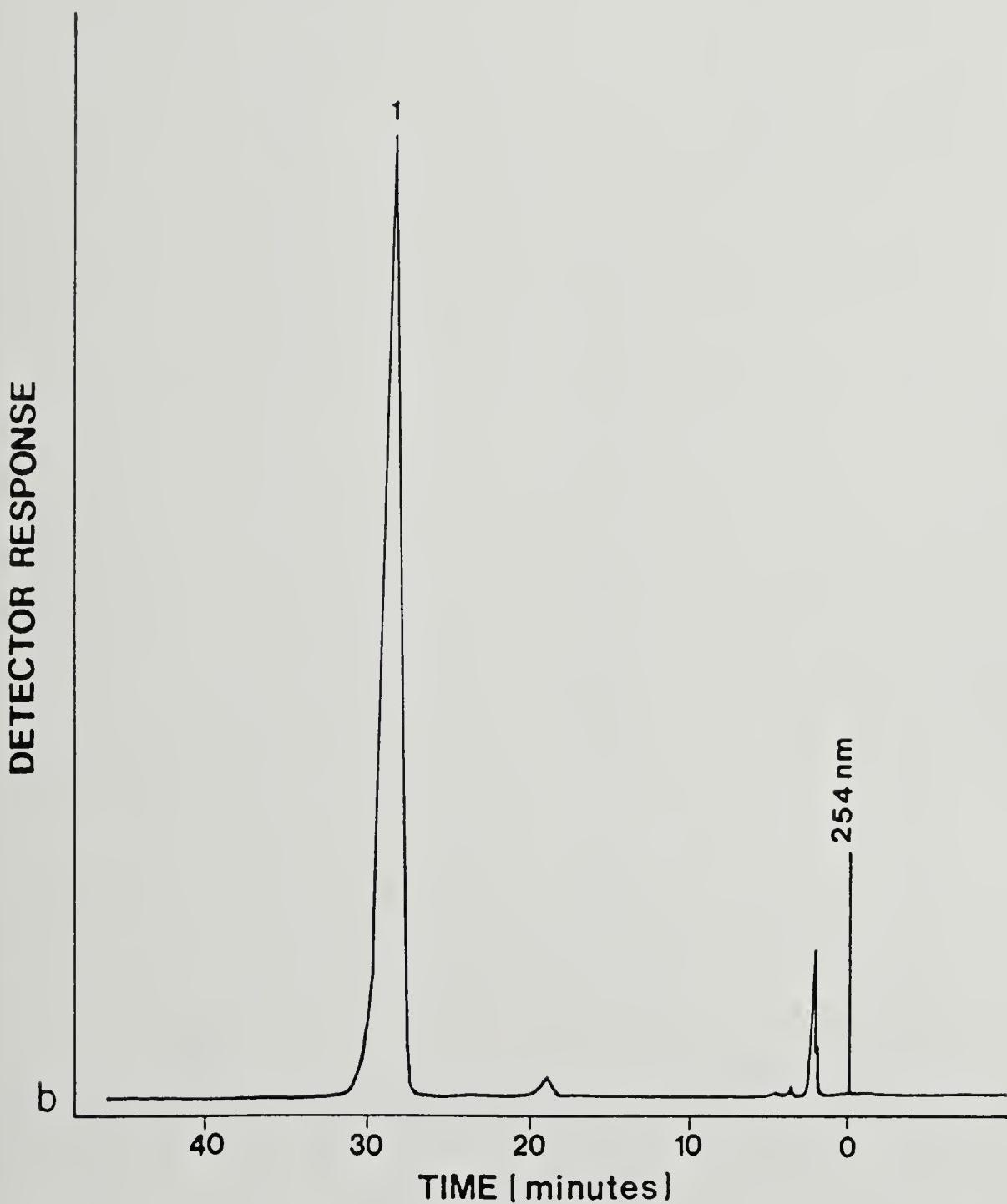


Figure 7B. Liquid chromatographic separation of GITC derivatized methphetamines synthesized from ephedrines. 7B. B= R-methamphetamine synthesized from S,R-ephedrine. Solvent system 3.

Clandestine Synthesis of Methamphetamine Derivatives

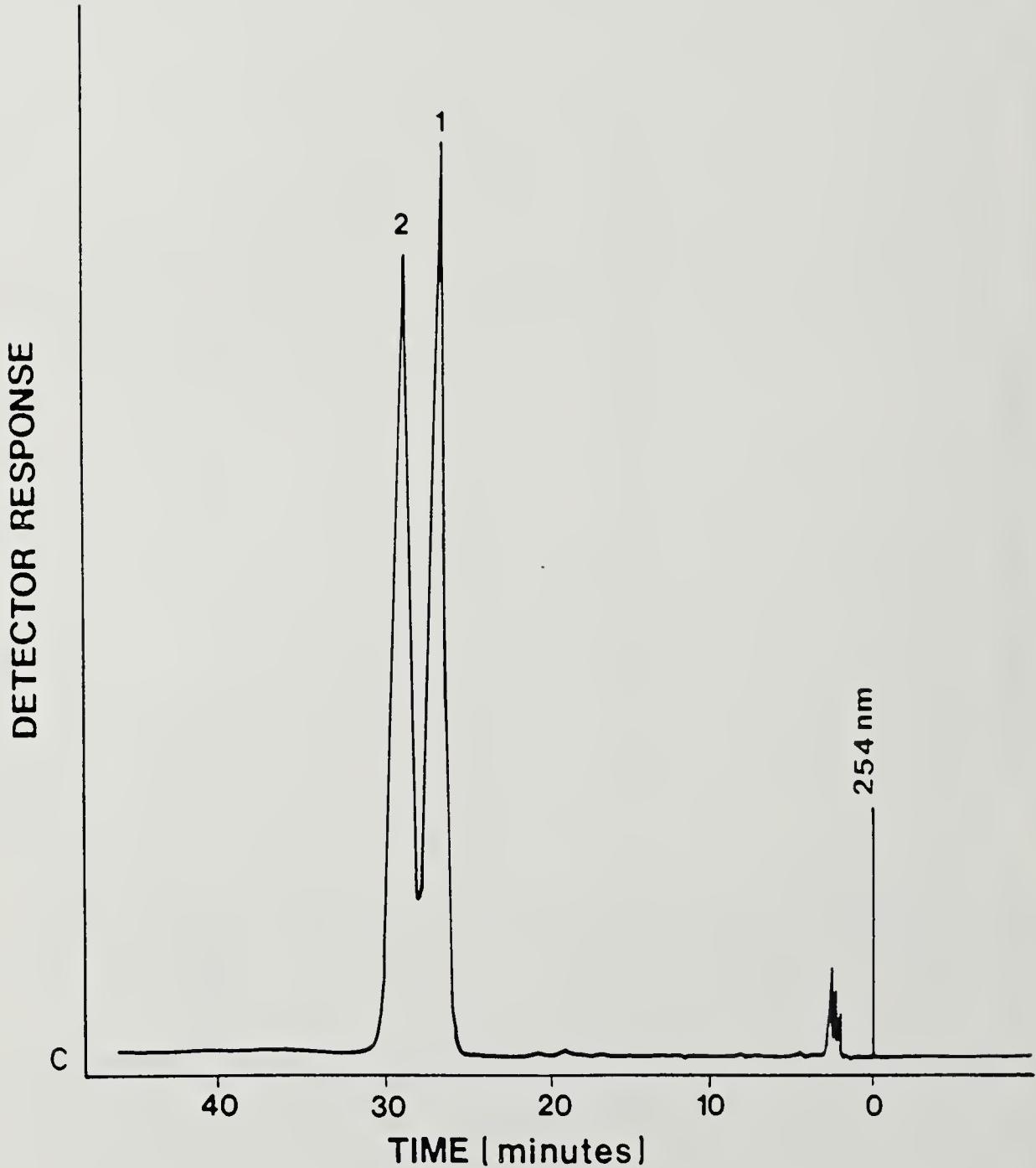


Figure 7C. Liquid chromatographic separation of GITC derivatized methphetamines synthesized from ephedrines. 7C.
C= S-methamphetamine (1) and R-methamphetamine (2).
Solvent system 3.

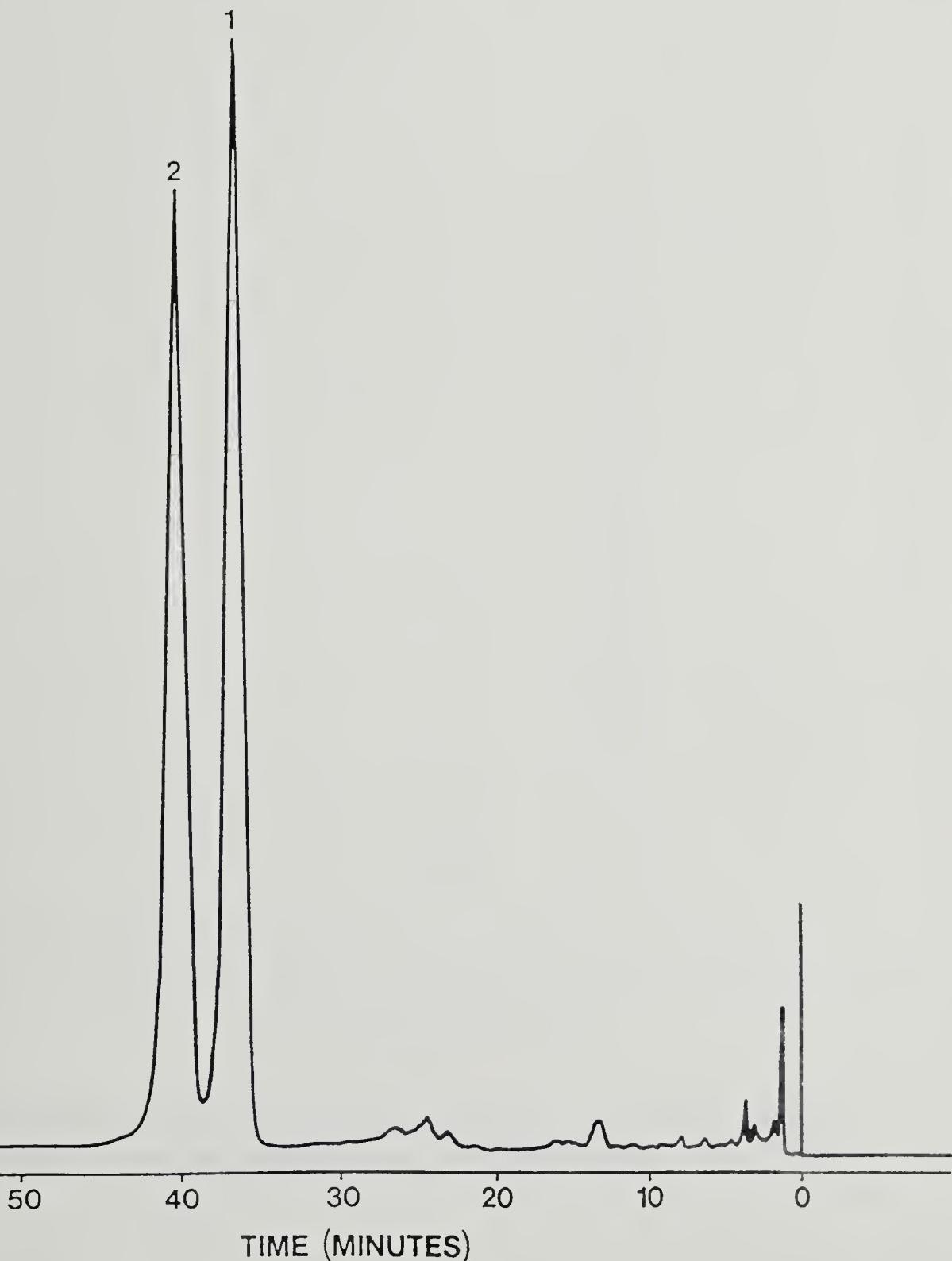


Figure 8. Liquid chromatographic separation of a GITC derivatized forensic samples from a clandestine laboratory. Peaks: 1 = S-methamphetamine, 2 = R-methamphetamine. Solvent system 3.

Clandestine Synthesis of Methamphetamine Derivatives

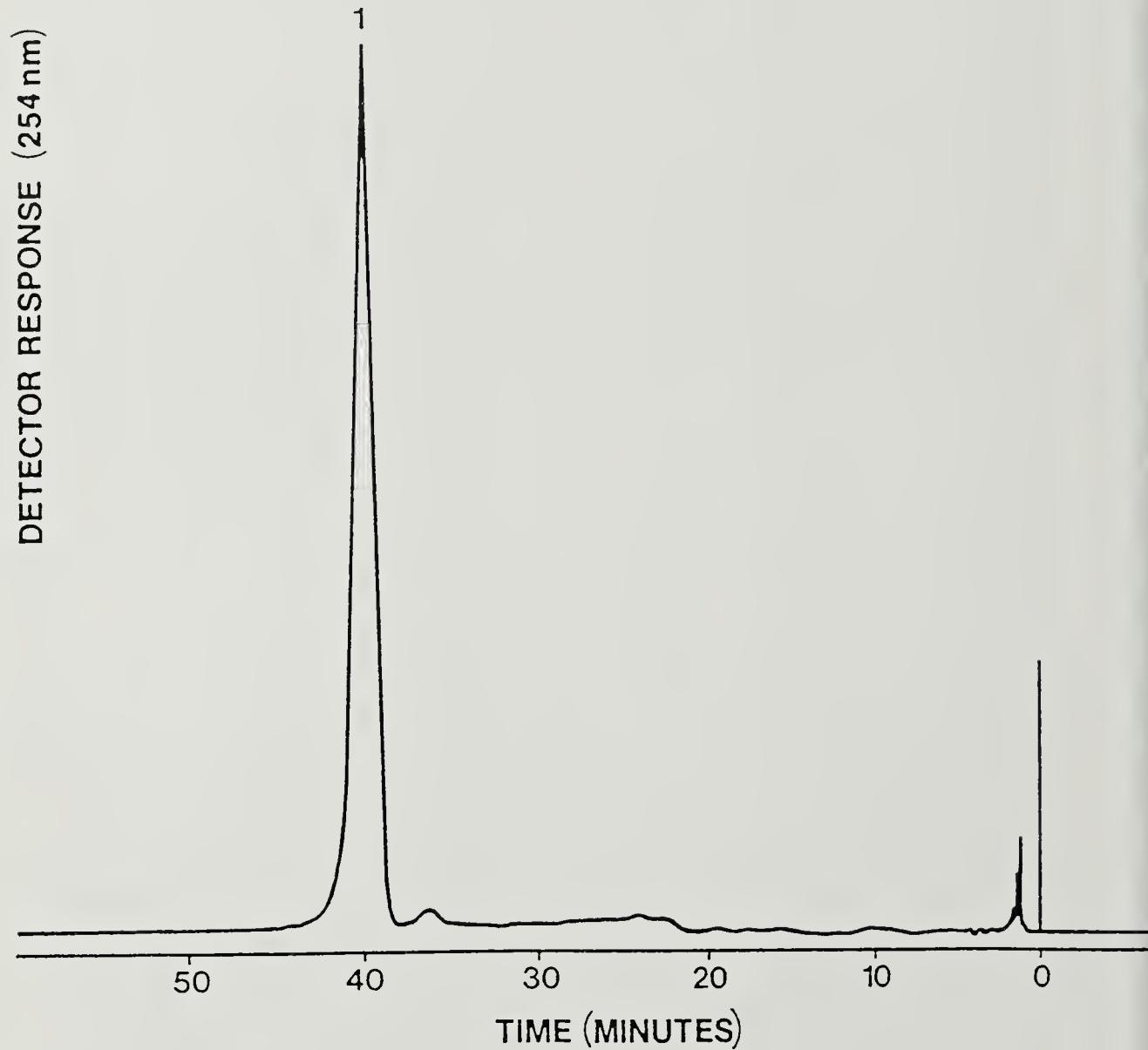


Figure 9. Liquid chromatographic separation of a GITC derivatized forensic sample. Peak = R-methamphetamine. Solvent system 3.

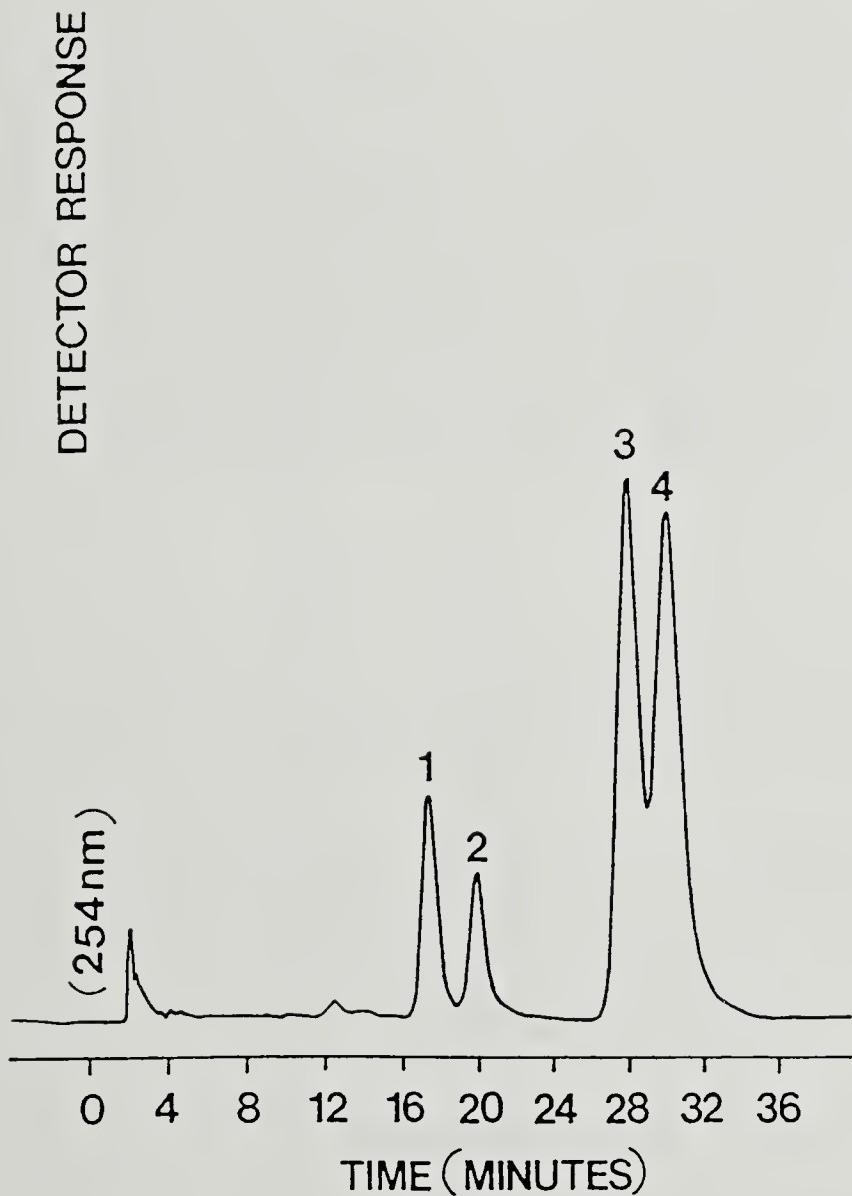


Figure 10. Liquid chromatographic separation of a GITC derivatized forensic sample. Peaks: 1=R,S-ephedrine, 2=S,R-ephedrine, 3=S-methamphetamine, 4=R-methamphetamine. Solvent system 3.

Clandestine Synthesis of Methamphetamine Derivatives

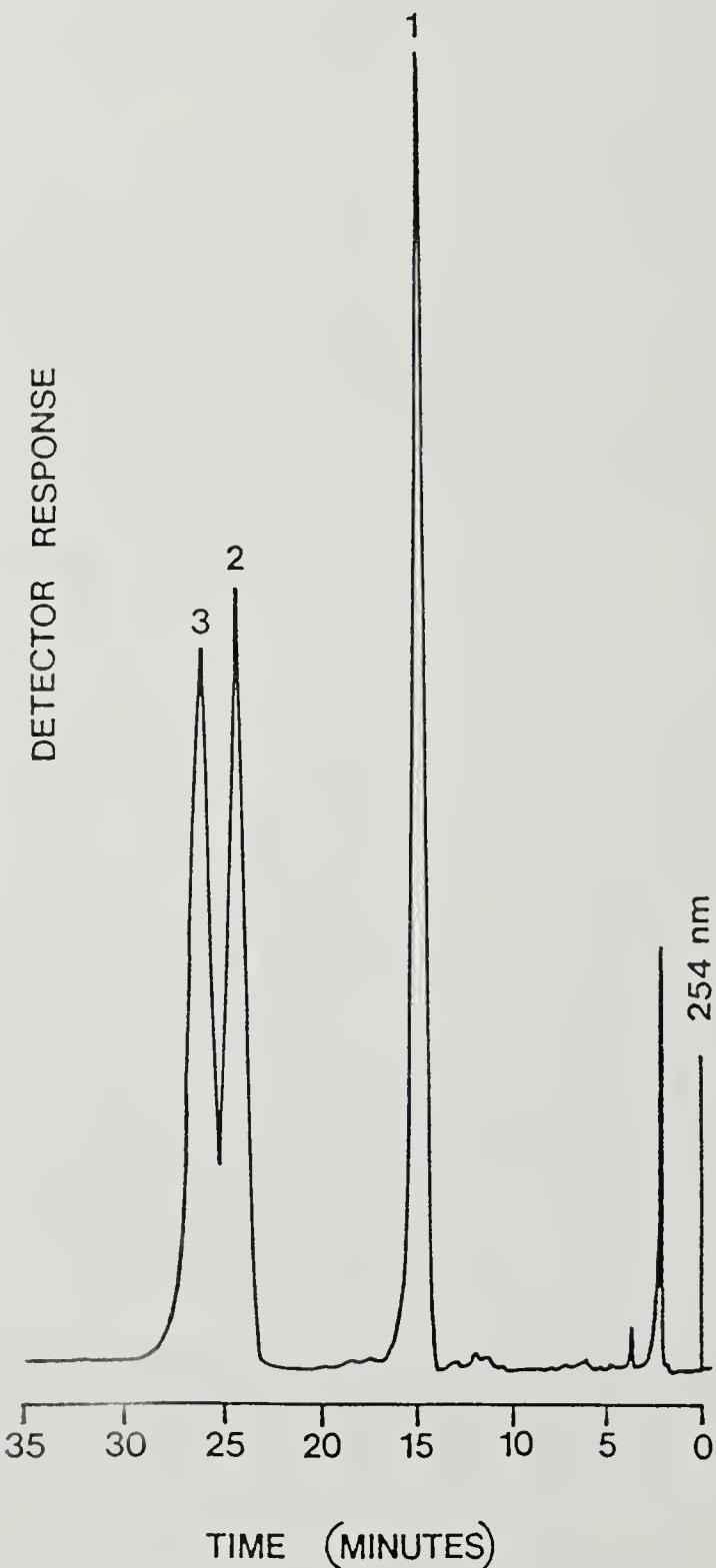


Figure 11. Liquid chromatographic separation of a GITC derivatized forensic sample. Peaks: 1=R,S-ephedrine, 2=S-methamphetamine, 3=R-methamphetamine. Solvent system 3.

CONCLUSION

The studies outlined above illustrate the utility of HPLC in determining the composition and stereochemistry of clandestine drug samples. The PIT precolumn derivatization method is useful to yield derivatives of sample components that have good liquid chromatographic retention properties and high UV detectability. Thus this method is useful for efficient determination of sample composition. The GITC precolumn derivatization method is useful to yield diastereomeric derivatives of sample components that can readily be separated and identified, thus allowing for the determination of the stereochemistry of components of the drug sample. When used together, these methods provide an efficient means to identify drug samples of common origin, differentiate legitimate pharmaceutical products from illicitly manufactured compounds, and identify potentially toxic contaminants or reaction side products present in clandestinely manufactured amphetamine and methamphetamine drug samples.

REFERENCES

1. Noggle, F. T.; DeRuiter, J.; Clark, C. R. *J. chromatogr. Sci.*. 1990, 28, 529.
2. Noggle, F. T.; Clark, C. R.; Davenport, T. W.; Coker, S. T. *J. Assoc. Anal. Chem.* 1985, 68, 1215.
3. Noggle, F. T.; DeRuiter, J.; Clark, C. R. *Anal. Chem.* 1986, 58, 1643.
4. Noggle, F. T.; DeRuiter, J.; Clark, C. R. *J. Chromatogr. Sci.* 1987, 25, 38.
5. Clark, C. R.; Wells, M. M. *J. Chromatogr. Sci.* 1978, 16, 332.
6. Lawrence, J. F.; Frei, R. W. *Chemical Derivatization in Liquid Chromatography, Journal of Chromatography Library*, Vol. 7. Elsevier, Amsterdam, 1976.
7. Noggle, F. T.; Clark, C. R. *J. Assoc. Off. Anal. Chem.* 1984, 67, 687.
8. Clark, C. R.; Barksdale, J. M. *Anal. Chem.* 1984, 56, 958.

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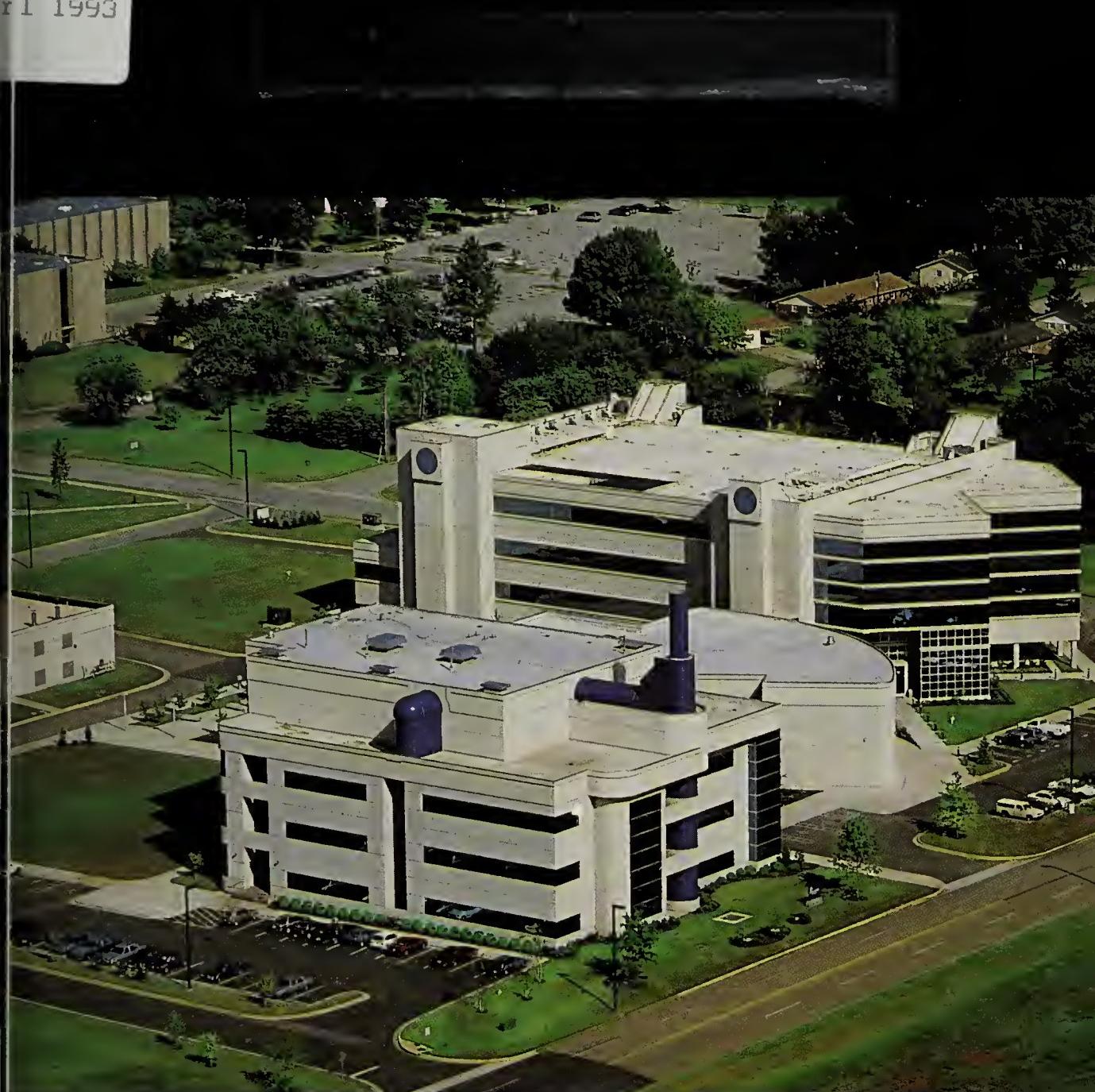
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NO. 2

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ABSTRACTS

Papers presented at the 70th Annual Meeting
The University of Alabama
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March 24-27, 1993

BIOLOGICAL SCIENCES

STREAM BIOASSESSMENT AS INDEPENDENT RESEARCH PROJECTS FOR UNDERGRADUATES. Cliff Webber, Matthew Floyd, Curry Dowdle and Matthew Allison. Dept. of Fisheries, Auburn University.

Independent research projects were conducted by three seniors, a biology major and two environmental science majors. The students had never conducted stream bioassessments prior to these projects. The projects included assessment of nonpoint source impacts to stream quality from strip mining, agricultural runoff and urban runoff. Rapid bioassessment procedures suggested by the U.S. EPA were utilized by each student. Students learned to identify macroinvertebrates to the family level. The same variables were measured in impacted streams and in a reference (undisturbed) stream from the same ecoregion. Based on percent comparability with the reference stream, biological integrity in impacted streams was determined. Once students completed their bioassessment, macroinvertebrate samples were identified to the generic and/or specific level by an experienced biologist, and biological integrity was recalculated. Stream quality, as measured by the students using family-level identification of macroinvertebrates, was comparable to that measured from the more detailed identifications.

TEACHING SCIENCE IN "INCLUDED" SETTINGS. Joseph D. George, Counseling and Clinical Programs, and Ernest D. Riggsby, Curriculum and Instruction, Columbus College, Columbus, GA 31907.

"Inclusion" refers to an instructional setting in which children with special needs and children with disabilities are taught in regular education classrooms alongside gifted and "normal" children. To date, science teachers have had little responsibility for education of children with special needs and children with disabilities. "Inclusion" will change this. It is here to stay. Science teachers at all levels of public schooling will be functioning in "included" settings.

Abstracts

INDUCTION OF MICRONUCLEI BY THERAPEUTIC ALKYL IMIDATES IN CYTOKINESIS-ARRESTED CHINESE HAMSTER CELLS. S. M. Torrence, V. B. Richardson, M. Abdullah, M. and B. Das Vishnu, Department of Biology, Tuskegee University, AL 36088.

The micronucleus (MN) assay is a widely used short-term test for the detection of putative clastogenic and aneugenic agents. Micronuclei may arise from chromatid fragments, the condensation of lagging acentric chromosomes or entire chromosomes. We employed the cytokinesis-block micronucleus (CBMN) technique developed by Fenech and Morley (1985) to assess chromosome damage induced by methyl acetimidate (MAI) and its bifunctional derivative, dimethyl adipimidate (DMA), in Chinese hamster Don cells. Our objectives were to establish dose response curves for binucleate cell induction by Cytochalasin B and to determine the relative frequency of MN in imidate-treated cells. Don cells were cultured 24 hours then exposed to imidates for 1 hour prior to reincubation in medium supplemented with Cytochalasin B. Analysis of the data suggests that acute exposure of proliferating cells to the lysine-specific alkyl imidates does not increase the frequency of MN in cytokinesis-arrested Don cells. These findings are consistent with the observation that the MN assay may underestimate the total chromosomal damage in cells exposed to agents known to perturb cellular proliferation kinetics. (Supported by NIH S06-GM08091).

CHARACTERIZATION OF FOLLICLE-SPECIFIC PROTEIN IN A STICK INSECT. B. H. Etridge and J. T. Bradley, Dept. Zoology & Wildlife Science, Auburn Univ., AL 36849. A. Cecchettini and F. Giorgi, Dept. of Biomedicine, Univ. Pisa, Italy.

During vitellogenesis, the fat body of Carausius morosus synthesizes and secretes two multisubunit vitellogenins (VG) which become sequestered by terminal follicles of the panoistic ovarioles. Separation of egg yolk polypeptides by SDS-PAGE reveals five vitellin (VG-derived) polypeptides with molecular weights ranging from 60 kD to 180 kD and a sixth polypeptide (A_4) at 93 kD. A_4 is not detectable in hemolymph proteins separated by SDS-PAGE and stained with Coomassie brilliant blue, suggesting that A_4 might be a follicle-specific protein (FSP). A rabbit polyclonal antiserum and mouse monoclonal antibodies prepared against A_4 were used in immunoblots in conjunction with fluorographs of polyacrylamide gels to analyze the polypeptides synthesized and secreted by fat body, whole staged follicles, and follicle cell layers isolated from staged follicles. *In vivo* and *in vitro* data indicate that A_4 is not produced by the fat body but is synthesized and secreted by follicular epithelium of all stages of vitellogenic follicles. This characterizes A_4 as a FSP. YP A_4 is the only sulfated follicle polypeptide. *In vivo* incorporation of ^{32}P -orthophosphate into the major egg yolk polypeptides showed that all five VG polypeptides are phosphoproteins; however, no detectable ^{32}P was incorporated into A_4 . Supported by Alabama NSF/EPSCoR grant #RII-8610669 and the Alabama Agricultural Experiment Station.

Abstracts

SPECIES DIVERSITY OF BENTHIC MACROINVERTEBRATES NEAR THE HEADWATERS OF THE CAHABA RIVER. Debra S. Moore and Ken R. Marion, Dept. of Biology, University of Alabama at Birmingham, AL 35294-1170.

Benthic macroinvertebrates were collected bimonthly from five sites on the Cahaba River in St. Clair, Jefferson and Shelby Counties, Alabama, from July 1991 through April 1992. Comparable riffle habitats were sampled using a Surber square-foot sampler for 10 thirty-second intervals with vigorous agitation of the substrate. Samples were cleaned through a U.S. standard No. 30 sieve, with the remaining detritus and organisms preserved in 70% ethanol for later sorting and identification. Organisms were identified to the lowest practical taxon. Shannon-Weiner species diversity indices were calculated at the family level. Results indicated that all sites showed relatively high diversity. Spring and summer indices were slightly higher. Community structure at all sites initially reflected organisms primarily found in relatively unimpacted waters, with ephemeropterans and trichopterans abundant. One site affected by sedimentation from nearby construction showed a decrease in diversity and number of species over time and an increase in organisms more tolerant of impacted waters. The preliminary data provided by this study will be helpful in serving as a biological baseline for monitoring long-term changes in both water quality and habitat integrity in a region of the Cahaba experiencing increasing urban encroachment.

ESTROGENS IN ECHINODERMS...? Gene A. Hines, Stephen A. Watts and *Peter A. Voogt. Department of Biology, U.A.B., Birmingham, AL 35294. *Laboratory of Chemical Animal Physiology, University of Utrecht, Utrecht, The Netherlands.

Echinoderms contain a variety of steroid hormones, including androgens and estrogens, which have well-known regulatory functions in higher vertebrates. The endogenous presence and production of androgens in echinoderms is well-documented, however the production of estrogens in echinoderms is unclear. Early studies utilized bioassays to demonstrate the presence of "estrogenic" compounds in several species of echinoderms. Later studies detected immunoreactive estrogens in several asteroids and echinoids. Recently, the presence of estradiol in the asteroid *Asterias rubens* was confirmed utilizing gas chromatography-mass spectrometry. Based on these studies and many physiological investigations *in vitro* and *in vivo*, the endogenous presence of estrogens in echinoderms is accepted. However, despite numerous metabolic tracer studies, the actual biosynthesis of estrogens in echinoderm tissues has remained an endocrinological enigma for many years. We have utilized radiolabeled steroid precursors and optimized techniques for investigation of steroid metabolism *in vitro*. Our studies have shown that echinoderms from the Northern Gulf of Mexico all synthesize a variety of androgens including androstenedione and testosterone. These androgens are metabolic precursors for the production of estrone and estradiol. Utilizing thin layer chromatography with multiple chromatographic solvent systems and product derivitizations we have demonstrated the conversion of radiolabeled androgen precursors to estrone and, tentatively, estradiol in somatic and gametic tissues of several asteroid species and in an ophiuroid, echinoid and holothuroid. Definitive identification (recrystallization to constant specific activity) is pending. This is the first indication that echinoderms may actually synthesize the estrogens which are present and physiologically relevant. Supported by NSF EPSCoR grant EHR9108761.

Abstracts

A PRELIMINARY BIOTIC SURVEY OF VILLAGE CREEK, JEFFERSON CO., AL. Roy D. Shaddix, Frank A. Romano and R. David Whetstone, Dept of Biology, Jacksonville State University, Jacksonville, AL 36265.

Village Creek is a small stream with its headwaters near East Lake and the mouth at Bayview Lake in Jefferson County, AL. This creek flows westerly through both municipal and industrial sections of Birmingham. Inputs into the stream are from natural sources, industrial and municipal runoff, storm drains and sewage treatment plants. The creek banks have been altered by being dredged, channeled to decrease flood problems and portions are now found in tunnels beneath streets and buildings. Some sections are somewhat pristine (site 2) while others are heavily trash littered. An assessment of water quality, the benthic macroinvertebrate community and a wetland delineation was performed during the fall of 1992 at 4 sites. The following water quality parameters were assessed (averages); temperature (24.2°C), NH_8 , (0.62 mg/l), NH_4 (0.65 mg/l), CO_2 (12.5 mg/l), Cl (41.25 mg/l), turbidity (0.0 NTU), and pH (7.6). Benthic invertebrates were collected employing the EPA's rapid biological assessment methodology and a cumulative index was calculated for each site and a rating was determined. Site 1 had a few group 1 animals and scored a fair rating while sites 2-4 were poor. Wetland delineation was determined by a plant (several obligate and facultative species), visual clue, and soil analysis (Munsell's Soil Color 10 YR). Overall, the streams health was fair to poor.

BIOTIC SURVEY: A PRELIMINARY STUDY OF JONES BRANCH, CLEBURNE CO., ALABAMA. Francine Hutchinson, Frank A. Romano, and R. David Whetstone, Dept. of Biology, Jacksonville State University, Jacksonville, AL, 36265.

A preliminary biotic survey of Jones Branch reveals a nearly pristine stream that may serve as a microcosmic stream model. An initial survey was performed in Oct-Nov and a second survey was completed in Feb-Mar. Water chemical analysis was determined using HACH Test Kit Model AL-36B; results for indicator substances were within EPA-acceptable ranges. Microbial testing, using Difco lactose and EC broths in 18mmX150mm sterile tubes fitted with Durham gas collection tubes, showed low to non-existent levels of coliforms, specifically Escherichia coli. Benthic invertebrates and algal samples were collected with standard equipment and evaluated using a dissecting scope and identification keys, then rated according to EPA rapid biological assessment methods. Results further indicated excellent stream health. Non-wetland status of soil sites was determined using a standard soil probe; soil samples were matched with Munsell's Soil Color Chart. Plant communities were determined by site surveys and collections that were prepared using standard botanical methods, identification keys, and jurisdictional wetland criteria. Animal species diversity was estimated using species-specific sign and censusing methods.

Abstracts

INTRACELLULAR LETHAL EXPRESSION OF THE pSa NUCLEASE GENE IN *Escherichia coli*. Wee-Yao Ng and A. K. Bej, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294-1170.

The nuclease (*nuc*) gene from a number of bacterial species such as *Staphylococcus aureus*, *Serratia mercescens*, and *Aeromonas hydrophila* code for nuclease enzymes which exhibit extracellular DNase activity. These nuclease enzymes contain a short signal-sequence at their -NH₂ terminal ends which is responsible for the extracellular transport of the proteins. Recently, such a *nuc* gene has been characterized from an *IncW* group plasmid, pSa. In an effort to investigate intracellular expression of the *nuc* gene in *E. coli*, two oligonucleotide primers were selected to clone the pSa *nuc* gene without its signal-sequence by PCR DNA amplification method. The amplified *nuc* gene was then fused with an inducible P_{lac}/Operator system in pSE 420 plasmid. The intracellular expression of the cloned pSa *nuc* gene lacking its signal-sequence was tested in *E. coli* by addition of IPTG and trace amounts of Ca²⁺ and Mg²⁺ in the growth media. The induction caused cell death due to the damage of the cellular nucleic acids by the nuclease enzyme, which was determined by the decline in cell numbers from 2 x 10⁶ to 1.5 x 10⁴ between 0-7h time period. The expression of the nuclease enzyme in *E. coli* was confirmed by western blot analysis using antisera raised against the nuclease enzyme from *S. aureus*. Also, the intracellular stability of the nuclease enzyme was ~2h as determined by ELISA assay. This model of programmed cell death function by the intracellular lethal expression of the nuclease enzyme can be utilized to engineer controllable, safer microorganisms for efficient removal of hazardous chemicals such as pesticides and herbicides, and other toxic wastes in the environment.

RELATIONSHIPS AMONG DOMESTIC POPULATIONS OF ESTRILDID FINCHES (POEPHILA). Dept. of Biology, Jacksonville State Univ. Jacksonville, AL 36265. Benjie G. Blair and Jeri W. Higginbotham.

Four species of Estrildid finches, indigenous to Australia, (Poephila gouldiae, P. bichenovii, P. acuticauda and P. guttata) were examined electrophoretically to determine genetic relationships. Poephila gouldiae has characteristics which are atypical of the genus. Because of that, it has been segregated into the monotypic genus, Chloebia, by some workers. Individuals of domestic populations were sampled non-invasively by collecting developing blood feathers as a tissue source. A total of fifteen enzyme systems were assayed and evaluated yielding five enzyme systems that provided consistently reliable results. One additional enzyme was found to be scorable but was only included late in the study. Domestic zebra finches (P. guttata) exhibited a great deal of polymorphism relative to reports of other avian taxa. Wild populations, when tested, should be expected to express even greater polymorphism. Cluster analysis, using the enzyme data, support the inclusion of P. gouldiae into the genus Poephila.

Abstracts

EFFECT OF COMMON CULTURE MEDIA ON THE GROWTH OF TWO-MOUTHED TETRAHYMENA (CILIOPHORA). G. Christopher & C.A. Sundermann, Department of Zoology & Wildlife Sciences, Auburn University, AL 36849.

Mutants of *Tetrahymena* are not uncommon. The exo⁻ mutant SB255 of *T. thermophila* has defects in mucocyst formation and docking. Three common culture media (proteose peptone, Medium 357, and yeast) were analyzed for total carbon, nitrogen, and inorganic elements. Cultures were grown at 28°C and fixed in 4% formalin at various times. Cells were counted and examined using Nomarski interference contrast microscopy. SB255 cultures grown in Medium 357 consisted of a mixed population of cells with either two mouths (2M) or one mouth. Immunofluorescence and scanning electron microscopy were used to examine the aberrant cellular morphology of the 2M cells. Cultures from the same original stock grown in Medium 357 (SBm) and in 1% proteose peptone (SBpp) had different percentages of 2M cells in 1, 2, 3, & 4 day old cultures. SBm had increasing percentages of 2M cells over the 4 day culture period. When grown in 1% yeast medium both SBpp and SBm cultures had increased percentages of 2M cells over a 4 day culture period. When grown in 0.1, 0.5, or 1% yeast medium for 2 days SBm cultures had more 2M cells in 1% than in either 0.1 or 0.5% yeast medium. After 4 days in 0.5% yeast SBm cell counts approximated those of 2 day 1% yeast cultures but the percent 2M cells remained similar to 2 day 0.5% yeast cultures. SBm cultures grown in Medium 357 or 1% yeast medium for 2 days had over 10 times the 2M cells in the inoculum while those in 1% proteose peptone had only two times the 2M cells in the inoculum. Phagocytosis of carmine red appeared to occur via both oral structures in the 2M cells. These findings suggest that both mouths are functional and that enriched media promote the growth of the two mouthed cells. This work was supported by a grant from the National Science Foundation (DCB-9018047).

KING HELMET SNAIL PREDATION ON SAND DOLLARS AT SAN SALVADOR, BAHAMAS. James B. McClintock and Ken R. Marion, Dept. of Biology, Univ. of Ala. Birmingham, AL 35294-1170.

We report the first quantitative observation of predation by the King Helmet snail *Cassis tuberosa* on the six-holed sand dollar *Leodia sexiesperforata*. Ninety percent of snails randomly examined on a soft sandy bottom site (4 m depth) at San Salvador, Bahamas, were feeding on sand dollars. Moreover, 95% of a randomly sampled population of sand dollars with spines intact (no dead clean tests) had evidence of recent snail predation. Snails apparently use their radula-equipped protrusible proboscis to drill a single 3-4 mm diameter hole in the oral side of the test of each sand dollar. The hole is drilled towards the anterior portion of the test, ensuring access of the proboscis to the soft internal tissues. Size-selective predation was not evident, as almost all sand dollars had drill holes regardless of test diameter. The results of this study indicate that populations of *L. sexiesperforata* can suffer high levels of mortality as a result of predation by *C. tuberosa*. Supported in part by the Bahamian Field Station, San Salvador, Bahamas.

Abstracts

BIOLOGICAL CONSIDERATIONS FOR THE CONTROL OF ZEBRA MUSSELS. Gerald L. Mackie, Department of Zoology, University of Guelph, GUELPH, Ontario N1G 2W1.

Biological characteristics of zebra mussels, Dreissena polymorpha, that need to be considered when developing control strategies include: (i) shell form; (ii) mode of life; (iii) reproductive potential; (iv) larval life cycle; (v) population dynamics; (vi) distribution, (vii) dispersal mechanisms; (viii) physiological requirements and tolerances; (ix) potential impact on the ecosystem; and (x) impact on society and the economy. Knowledge of its body form is important because it is not only necessary to know what the adult looks like, but how it differs from other nuisance species, especially the closely related "quagga mussel" and the brackish water, Mytilopsis leucophaeta, as well as the Asiatic clam, Corbicula fluminea. The zebra mussel is strongly byssate enabling it live on almost any hard surface but several factors, including material composition, water velocity, and temperature, affect its ability to adhere to hard surfaces. Physical and chemical characteristics of the water must be examined in order to determine the potential for infestation at a facility. Minima and maxima temperatures greatly affect the periods of reproduction and settlement, as well as the growth rates of adults. Most adults live for about 2 years but growth rates vary greatly even within the Great Lakes. Variations will be even greater in the southern United States because of higher average temperatures. Standing crops as high as 500,000 m⁻² were reached in parts of the Great Lakes. At some sites (e.g. Lake St. Clair), population peak densities occurred about five years after their introduction. High temperatures in warmer climates may not only limit population densities but the period of time needed to reach peak densities. Infestations are interfering with the normal metabolism of native unionid clams and there is potential of the unionid clam populations being reduced or even eliminated from major lakes and rivers in which zebra mussels thrive. Zebra mussels will also infest Asiatic clams which will act as a substrate for zebra mussels in many facilities. Although zebra mussels themselves will help to limit densities of Asiatic clams within facilities, control strategies must include those for Asiatic clams. The control options employed must be compatible with environmental standards for municipalities, states, and federal agencies in order to keep socio-economic impacts to a minimum.

PHYSIOLOGICAL ACROSOME REACTIONS IN CAPUT EPIDIDYMAL SPERM. Beth E. Biegler, David J. Aarons and Gary R. Poirier, Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, AL 35294-1170.

Murine caput sperm are considered immature and thus unable to fertilize oocytes. It has been shown, however, that these sperm, if incubated under capacitating conditions and washed, will bind to whole zonae. Capacitated cauda sperm not only bind to zonae but undergo zonae-induced acrosome reactions, while caput sperm failed to acrosome react. These caput sperm were incubated under capacitating conditions, but not washed. Since washing increased the binding capacity of caput sperm, it was of interest to determine if washing would increase their ability to acrosome react in response to a zonae stimulus. It is shown here that incubated, washed caput sperm will acrosome react in response to both solubilized zonae and immunoaggregation of a zona binding site. In addition, the material removed from caput sperm by washing will block induced acrosome reactions of cauda sperm. The data indicate that murine caput epididymal sperm are able to be capacitated and to undergo a physiologically-induced acrosome reaction.

Abstracts

MECHANISM FOR LONG-TERM CUMULATIVE BIOLOGICAL EFFECTS OF EM RADIATION.
T. E. Bearden, A.D.A.S., 2311 Big. Cove Rd., Huntsville, AL 35801.

EM potentials, not force fields, are the primary causes of EM phenomena. The two major postulates of the classical EM bioeffects model are falsified, and a corrected model presented. Whittaker/Ziolkowski (WZ) decomposition of the scalar EM potential yields a harmonic structure of bidirectional EM wave pairs, with sum and product sets, used by the living organism for operations of mind, thought, long-term memory, and deep cellular control. Both a species quantum potential (SQP) and a personal quantum potential (PQP) exist in the body. Popp's master cellular control system (MCCS) operates in the PQP. Newton's third law requires that the common photon interaction be a graviton (photon/antiphoton pair) interaction. Antiphotons from the organism's sustained low-level stress interactions provide slowly cumulating stress-relieving WZ signals in the PQP/MCCS. When these signals breach the quantum threshold, weak EM currents are provided to the affected cells as dedifferentiation orders. Sustained low-level EM radiation, contaminants, and pollutants in the blood fluid interfere with its H-bonding interaction with hemoglobin, resulting in sustained cellular oxygen deficiency. The most affected cells eventually receive feedback signals to dedifferentiate back toward their anaerobic ancestry. The first step, partial separation from the MCCS, causes loss of central PQP control of growth of those cells, and other changes, resulting in cancer. Irradiation by WZ counter-structures can cause cellular redifferentiation, total remission of the cancer, and prevention of metastasis, as shown by Priore, Pautrizel, et al under rigorous protocols. The "extended EM WZ antidote" is a totally new therapeutic modality for serious scientific investigation.

BIOTIC SURVEY OF CANE CREEK, CALHOUN COUNTY, AL (PRELIMINARY)
Loretta L. Weninegar, Dept of Biology, JSU, Jacksonville, AL 36265.
Dr. Frank A. Romano and Dr. R. David Whetstone, Dept of Biology,
JSU, Jacksonville, AL 36265.

Preliminary analyses including water chemistry and benthic macroinvertebrates of Cane Creek (Calhoun County, AL) were performed in Fall 1992 and Winter 1993 to determine the general health of the stream. Data was collected utilizing EPA standard methodology for rapid biological assessment and Hach's water quality kit. Values for NH₃, CO₂, Cl₂, DO, CaCO₃, NO₂, pH, temperature, and turbidity were determined at 6 sites from headwaters to the mouth. Macroinvertebrates, including indicator species, at the same 6 sites were also collected. The chemical analysis yielded the following averages for the stream: NH₃ -0.01 mg/L, CO₂ -12.0 mg/L, Cl₂ -20.0 mg/L, DO -9.5 mg/L, CaCO₃ -119.7 mg/L, NO₂ -0.24 mg/L, pH -7.5, temperature -15.6 C, and turbidity -0.08 NTU. The benthic macroinvertebrate study yielded a cumulative index value of 10.9. Based on both the water chemistry analysis and the benthic study the stream's health is rated as fair and it degrades from headwaters to mouth.

Abstracts

EMBRYONIC CHICK PANCREATIC ORGAN CULTURE SYSTEM: VIABILITY AND AMYLASE RELEASE. Connie A. Meacham, Adriel D. Johnson, Nina S. German and Selena S. Williams, Dept. of Biological Sciences, University of Alabama in Huntsville, Huntsville, AL 35899. Jacqueline U. Johnson, Dept. of Food and Animal Industries, Alabama A & M University, Normal, AL 35762.

Studies were conducted using an embryonic chick pancreatic whole organ culture system to characterize lactate dehydrogenase (LDH) release, amylase (AMYL) release, and histological integrity over time. Organ cultures were prepared using 18 day old embryonic chicks. LDH and AMYL activities in the media during 2,4,8,12,16,24, and 48 hours incubation periods were examined. Total LDH release ranged from 47 to 290 U/ml and LDH release per unit weight of tissue ranged from 3 to 20 U/ml/mg, during the incubation periods. Total AMYL release and AMYL release per unit weight of tissue ranged between 714 to 10,087 U/L and 48 to 694 U/L/mg, respectively, over the incubation times. Under the conditions of this study, the embryonic pancreatic tissue remains histologically intact and functional as measured by LDH and AMYL activity in the medium during the incubation periods. This whole organ culture system may serve as a functional model for the study of cellular changes in pancreatic function by various neurotransmitters and hormonal agents known to alter secretion in vivo.

DESCRIPTIONS OF A GRAVITATIONALLY INDUCED OSCILLATORY MOTION FROM NEWTON THROUGH EINSTEIN. Govind K. Menon and J.H. Young, Dept. of Physics, Univ. Al. at B'ham, Birmingham, AL. 35294.

The gravitationally induced oscillatory motion of a test mass along the symmetry axis of a massive ring has been examined from a number of approaches for motion near the plane of the ring. Descriptions of the motion based on (A) purely Newtonian, (B) special relativistic dynamics plus Newtonian gravity, (C) special relativistic dynamics plus pseudo-Newtonian gravity, (D) weak field general relativity, and (E) exact general relativistic treatments will be presented. The roles of relativistic dynamics and energy density on the oscillatory frequency in the escalating levels of the description will be presented and their significance will be discussed.

Abstracts

ADAPTIVE COLD TOLERANCE RESPONSE (CTR) IN *Vibrio cholerae*. Kiran Chava and A. K. Bej, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, AL 35294-1170.

Vibrio cholerae, the causative agent for cholera, has been reported to enter into a viable but non-culturable state during cold seasons. The adaptation and survival of this bacterium in cold temperatures is due to physiological and metabolic changes within the cell. To determine the CTR, an exponentially grown culture of *V. cholerae* was transferred to a M9 minimal medium containing ^{35}S -methionine, and incubated at 37°C, 25°C, 18°C, or 10°C for 15 min or 60 min, to radiolabel total cellular protein. Following incubation, total protein from the cold-adapted and unadapted cells of *V. cholerae* were subjected to electrophoretic separation in a 17.5% SDS-PAGE, and autoradiography was performed to determine the protein profile. A significant decrease in the synthesis of a 24 kDa protein and marked increase in a 23 kDa protein were observed. In an attempt to clone the gene that encodes cold-inducible protein in *V. cholerae* two oligonucleotide primers were designed from the reported nucleotide sequence of the cold-inducible *cspA* gene in *Escherichia coli*. The PCR amplified DNA of molecular weight approximately 0.350 kb was cloned in a pCR 2000 plasmid vector, and DNA sequence analysis was performed. The deduced nucleotide sequence of the amplified DNA fragment showed significant homologies with the *E. coli cspA* gene indicating the presence of a *cspA*-like gene in *V. cholerae*. Further analyses of the cold-inducible proteins and the underlying genetic control for adaptation in the cold environment may help to understand the possible physiological changes during the viable but non-culturable state of this pathogen.

CHARACTERIZATION OF MONOCLONAL ANTIBODIES PRODUCED AGAINST TETRAHYMENA LWOFFI CILIA. B. Estridge, A. Southwood, M. Mayo, and C. Sundermann. Dept. Zoology & Wildlife Sciences, Auburn University, AL 35849 USA.

Mouse monoclonal antibodies (MAbs) produced against Tetrahymena lwoffi cilia were characterized using immunocytochemical and immunoblotting techniques. T. lwoffi, T. pyriformis (ATCC 30005 and 30327), and T. thermophila (ATCC 30008 and an exo-mutant SB255, a gift of E. Orias) were used to test MAb reactivity by enzyme-immunostaining and immunofluorescence. Two general staining patterns were observed: 1) species-specific staining of cilia T. lwoffi (three MAbs), and 2) staining of somatic and oral ciliary structures in all five strains (five MAbs). The three LW species-specific MAbs reacted differently with immunoblots of reduced and non-reduced ciliary polypeptides, indicating that the reactive epitope is altered by reducing agents. The species-specific MAbs did not react with T. lwoffi cytoskeletal preps, indicating that these MAbs are specific for a surface membrane antigen. The five MAbs that reacted with cilia of all strains reacted also with cytoskeletal preps and with bands that co-migrated with ciliary tubulins in SDS-PAGE. Only three of these MAbs reacted with purified calf brain tubulin. Supported by the National Science Foundation (Grant DCB-9018047) and the Alabama EPSCoR Program in Molecular, Cellular and Developmental Biology (RII-8610669).

Abstracts

ESTROGEN EFFECTS ON EPIDERMAL GROWTH FACTOR (EGF) LEVELS. Katherine A. Mousel, D. M. Moriarity, and P. S. Campbell, Department of Biological Sciences, The University of Alabama in Huntsville, AL 35899.

Since human saliva changes composition during the reproductive cycle (*J. Dent. Res.* 51:1212, 1972), the possibility that salivary glands may be an estrogen target organ was investigated. Using the rat as a model, it is evident that salivary gland tissue exhibits a specific estrogen receptor which can be modulated by exogenous and endogenous estradiol. It has since become apparent that EGF, rather than estrogen, is the uterotrophic factor in the estrogenized uterus and that estrogen acts to promote uterine growth through induction of the EGF receptor in uterine cells (*J. Biol. Chem.* 260:9820, 1985). Since the EGF-rich submandibular salivary gland has the greatest concentration of estrogen receptor and since estrogen serves to orchestrate dependent events of the female reproductive cycle through temporal stimulation of hormone receptor inductions and hormone secretions, we hypothesized that estrogen-mediated EGF release from the submandibular gland might be another critical link in the multifaceted physiological regulatory loop exhibited by estrogenic hormone. Thus, serum and submandibular gland EGF levels at time intervals after estrogen administration were measured by RIA. Because of assay sensitivity limits and low serum EGF levels in females, adult male rats were used. A time coincident reciprocal relationship exists between serum and glandular EGF levels suggestive of an estrogen-regulated EGF release process. Consequently, we suspect that endogenous estrogen can serve to regulate serum EGF levels in concert with the appearance of uterine EGF receptor in the stimulation of uterine growth. (Supported by N.I.H. grant #1R15HD26887-01A1.)

FETUIN: A ZONA MIMIC. B. George, B. Biegler, D. Aarons, G.R. Poirier, Dept. of Biology, Univ. of Ala. at B'ham, Birmingham, AL 35294-1170.

Fetuin, a complex glycoprotein with antitrypsin activity, has biological features similar to ZP3. ZP3, one of the three glycoproteins of the murine zona pellucida plays a major role in the fertilization process. It functions to bind sperm and to induce the acrosome reaction in the bound cells. ZP3 triggers the acrosome reaction in the bound cells by aggregation of the zona binding sites. We show here by indirect immunofluorescence that fetuin, like ZP3, binds in the acrosomal cap region and will induce capacitated cells to acrosome react. Furthermore the same proteinase inhibitor blocks ZP3 and fetuin binding suggesting that ZP3 and fetuin bind to the same sites on the sperm. To demonstrate that fetuin induces acrosome reactions by aggregation, pronase-treated fetuin was added to capacitated sperm. These sperm acrosome reacted when the bound fetuin was aggregated by a polyclonal anti-fetuin antiserum. These data indicate that fetuin can be used as a substitute for ZP3. Zona mimics are useful for studying mechanisms for sperm binding and acrosome reactions and may at least, on a theoretical basis, be used to induce acrosome reactions prematurely reducing the possibility of successful fertilization.

Abstracts

BIOSYNTHESIS OF SEX STEROIDS IN THE ECHINOID LYTECHINUS VARIEGATUS (LAMARCK). A.S. Hasan, G.A. Hines and S.A. Watts, Dept. of Biology, U.A.B., Birmingham, AL 35294

During the last twenty years much of the research in echinoderm steroid biochemistry has involved asteroids only. Little is known about the steroid biochemistry of other major groups of echinoderms. In what represents only the second study of steroid biosynthesis in an echinoid, L. variegatus were collected from mixed grass beds in St. Joe's Bay, Florida, during November, 1992, following their apparent late summer spawning season. Steroid biosynthesis was compared among various tissue types *in vitro*. Isolated cells and mixed tissue preparations were incubated with tritiated androstenedione. Steroid products were then extracted and identified using thin layer chromatography and a radioisotope imaging scanner. In preliminary experiments, all tissues examined had the ability to convert the precursor to other steroid products. The rates of conversion of the radioactive precursor were highest in the gut followed by the body wall, gonads and coelomocytes. The major product produced initially in all tissues was testosterone. Other androgen products include epiandrosterone, 5α -DHT, and 5α -androstane-dione. In addition, the limited synthesis of esterified androgens, estrogens, and water soluble steroid conjugates were presumably observed, although positive identification has not been accomplished. Limited conversion was seen in the coelomocytes. No obvious sex-specific differences in steroid metabolism were seen; this may be related to their post-spawning stage of reproduction. Further studies will provide tissue-specific rates of precursor conversion and identify other unknown steroids and steroidal derivatives. Supported by NSF EPSCoR grant EHR 9108761.

SEASONAL DIETARY HABITS OF THE NINE-BANDED ARMADILLO IN SOUTHERN ALABAMA. Lisa L. White and David H. Nelson, Dept. of Biology, University of South Alabama, Mobile, AL 36688.

The stomach contents of 151 specimens of the nine-banded armadillo (Dasypus novemcinctus) from southern Alabama and the surrounding area were analyzed to determine seasonal dietary habits. Armadillos were found to be opportunistic feeders, consuming mainly insects in all seasons of the year. Additional food items included other invertebrates (mostly arthropods) and some vertebrates. The most important groups of insects in armadillo diets were represented by Order Hymenoptera (ants), Order Isoptera (termites), Order Coleoptera (beetles), and Order Diptera (flies). Minor food items included caterpillars, grasshoppers, crickets, spiders, scorpions, centipedes, earthworms, lizards, and snakes. Some wild fruits were also consumed. Very few seasonal trends were apparent in the diets of armadillos in the study area. Differences in the results of this study and the results of previous dietary surveys appear to reflect the abundances of potential prey items and the availabilities of these prey items to armadillos.

Abstracts

THE EFFECT OF HYPERTONIC DILUENTS AND RATE OF THAW ON MOTILITY CHARACTERISTICS AND POST-THAW VIABILITY OF FROZEN BUCK SPERMATOZOA. Jacqueline U. Johnson, Gerald Frank, Jeffery Dorsey, Dept. of Food Science and Animal Industries, Alabama A&M University, Normal, AL. 35762. Adriel D. Johnson, Dept. of Biological Sciences, University of Alabama in Huntsville, Huntsville, AL 35899.

Cryopreservation techniques were employed to examine the effect of different media and buffers on Caprine (buck) semen. Buck semen was processed for freezing using two types of extenders (skim milk and Tris-based). Each extender varied in composition and concentration of cryoprotectant agent (glycerol). Aliquots of semen were treated with different extenders and processed by cooling gradually to 5°C; further dilution, equilibration and packaging of semen in 0.5 ml straws. Freezing was done in liquid nitrogen (LN2) vapor and final storage in LN2 (-196°C). Semen was evaluated before freezing and again post-thaw to look at % motility and post-thaw viability with the rate of thaw considered as a factor. Based on the results of this study, there is suggestion that the type of extender affects sperm survival, and rate of thaw (waterbath: 35°C-20 sec vs. 35°C-65 sec) affects % sperm motility. Further studies are necessary to determine the relative efficacy of any one medium and to establish repeatability of procedures.

PARASPORAL INCLUSIONS OF BACILLUS THURINGIENSIS SUBSPECIES FINITIMUS. LaJoyce H. Debro, Dept of Biology, Jacksonville State University, Jacksonville, AL 36265.

Bacillus thuringiensis subspecies finitimus produces two parasporal inclusions with unique antigenic properties. The major inclusion is formed within the exosporium and a minor, small parasporal body is formed outside the exosporium. Both inclusions are sporulation specific products but antigens for the enclosed inclusion appear earlier during sporulation than antigens specific for the free inclusion. The enclosed inclusion is hydrophobic and spores plus enclosed inclusions persist in an aqueous environment after free inclusions have settled. The enclosed inclusion is produced only when a resident plasmid of 98md is present. Transfer of this plasmid into B. cereus resulted in transformants that produced hydrophobic exosporium enclosed inclusions. These results lead to the attractive hypothesis that subspecies finitimus is a candidate for donating hydrophobicity genes that can control the environmental distribution of parasporal inclusions of strains of Bacilli. This work was supported by a Faculty Research Grant provided by Jacksonville State University.

Abstracts

ECOLOGY OF TWO NATURAL POPULATIONS OF ELIMIA ACUTOCARINATA, LEA (MOLLUSCA: GASTROPODA) AT CAVE SPRING, GA. Frank A. Romano, Dept of Biology, Jacksonville State University, Jacksonville, AL 36265.

Two populations of Elimia acutocarinata were discovered at Cave Spring, GA living in the effluent of a freshwater spring (Cave Spring Pond and creek-CS) and in a normal watershed stream (Little Cedar Creek-CC). Environmental parameters of CS are considerably different than CC especially with respect to water temperatures, since this water is warmer in the winter and cooler in the summer. In 1920-21 the city of Cave Spring built a swimming pool in CS effectively isolating the CS population. Considering these differences and that temperatures are highly correlated to an animal's physiology, one would expect the populations might show life history variations. Plotting shell length measurements versus time of collection for both populations reveals that this animal is biennial, living up to three years of reproducing in their second year. Juveniles hatch at approximately 0.755 mm and grow continuously becoming adults at approximately 7 mm in length, attained during their 2nd year of growth. CS juveniles grow (mm/day) at a rate of 0.043 during the summer and fall and falls to 0.03 during the winter while adults averaged 0.001. CC juveniles growth rate (mm/day) is 0.46 during their first summer and 0.01 during the winter. CS adults are bivoltine reproducing in both spring and fall while CC adults are univoltine, reproducing only in the spring of each year. Fecundity (average #eggs/adult) of the snails also differs between populations. CS adults produce 6.07 eggs/adult and 9.25 during their two reproductive periods while CC adults produce 8.82 during their single reproductive period.

THE EFFECTS OF COPPER NITRATE ON GROWTH, FOOD CONSUMPTION, EGG MASS DEPOSITION, AND EMBRYOGENESIS IN THE PULMONATE SNAIL *PHYSELLA CUBENSIS*. S. Hart, S. Archie, D.L. Thomas and J.B. McClintock, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294-1170.

PhySELLA cubensis exposed to a variety of concentrations of copper nitrate showed both acute and chronic responses. Juveniles and adults exposed to high (0.05 %) and medium-high (0.01%) concentrations of copper nitrate suffered complete mortality within 3 days. Food consumption and growth of individuals exposed to medium low (0.005%) levels of copper nitrate were reduced when compared to snails exposed to low (0.001%) levels or control treatments. Moreover, mature snails exposed to medium-low levels of copper nitrate produced only half the number of egg masses as individuals exposed to low levels or water alone. Embryonic development was retarded in all copper nitrate treatments with only embryos exposed to low levels of copper nitrate and control individuals hatching. These studies indicate that populations *P. cubensis* may serve as useful bioindicators of heavy metal water contamination, and that very low concentrations of copper nitrate can have a dramatic impact on aspects of the biology of this common snail.

Abstracts

BIOACTIVE PROPERTIES OF ECHINODERM BODY WALL EXTRACTS: FEEDING DETERRENCE, ANTIFOULING AND ANTIMICROBIAL ACTIVITY. Patrick J. Bryan, James B. McClintock, Stephen A. Watts, Ken Marion, Joseph J. Gauthier, and *Thomas S. Hopkins. The University of Alabama at Birmingham, Birmingham, AL 35294-1170 and *University of Alabama, Tuscaloosa, AL 35486.

Body wall tissues of 25 species of echinoderm were tested for feeding deterrence using two species of marine fish (Lagodon rhomboides, Cyprinodon variegatus) and a spider crab (Libinia emarginata). Uniform pieces of body wall tissue of 14 echinoderm species caused significant feeding deterrence in at least two model predators. Ethanolic body wall extracts embedded in alginate pellets at an ecologically relevant concentration (3 mg/ml) caused significant feeding deterrence (17 of 20 species tested against L. rhomboides). Ethanolic extracts of the body wall tissues of all 25 echinoderms significantly inhibited the settlement of barnacle (Balanus amphitrite) and bryozoan (Bugula nerita) larvae at a concentration of 3 mg extract/ml seawater, and in some species, at concentrations orders of magnitude below that occurring in the body wall. Extracts of 18 species of echinoderms also inhibited microbial growth in at least one or more of 18 microbial species (including fungi, marine and non-marine bacteria). These results indicate that echinoderms have bioactive chemicals sequestered in their body walls which augment morphological defenses. These chemicals may have multiple functions including the prevention of infection, fouling, and predation. Supported by NSF EPSCoR grant # EHR 9108761 to J.B.M., S.A.W., K.R.M. AND T.S.H.

BURROWS OF THE GOPHER TORTOISE (GOPHERUS POLYPHEMUS) IN BALDWIN COUNTY, ALABAMA. David Nelson, Lisa White and Suzie Hatten, Department of Biological Sciences, University of South Alabama, Mobile, AL 36688.

To assess the distribution of gopher tortoises within Baldwin County Alabama, a systematic field survey of tortoise burrows was conducted from February to August, 1992. In each non-wetland township, we surveyed available sites in which tortoises might be expected to occur. Both public and private lands were sampled. A line-transect burrow count system was employed; each burrow was measured and characterized as "active," "inactive" or "old." During 24 days in the field, we sampled a total of 124 gopher tortoise burrows in 49 townships and drove a total of 4,274 miles. A majority of the 95 transects (61%) disclosed no tortoise burrows. Of the 124 burrows encountered, 61% were old, 27% were active and 11% were inactive. Juvenile burrows accounted for only 3% of those observed. Preliminary data analyses indicate that most surveys represent declining populations. Effects of predation, soil types and land management are discussed. A similar study of Mobile County in 1991 revealed 392 burrows. In Baldwin County, 28 more transects were conducted but only 124 burrows were encountered (68% fewer than in Mobile County).

Abstracts

A REVIEW OF CRETACEOUS BIRDS OF ALABAMA AND INITIAL REPORT OF A POSSIBLE NEW SPECIES. James Lamb, The Alabama Museum of Natural History, P.O. Box 870340, Tuscaloosa, AL 35487.

Previous reports of cretaceous birds from Alabama refer to a single fragmentary humerus from the Mooreville Chalk Fm., described as Plegadornis antecessor (Wetmore, 1962), and as Ichthyornis antecessor (Olson, 1975). A large collection of additional material, also from the Mooreville Chalk, is referable to Ichthyornis. A small, gracile and larger, robust morph exist within this population (per.obs. and D. Womochel, per.comm.). It is presently unclear whether this represents sexual dimorphism or the presence of two species. The absence of Hesperornis, common in the Niobrara Chalk of Kansas, is puzzling. This may represent a sampling bias due to differences in the age of the Niobrara (Coniacian--Santonian), where Hesperornis is most abundant, and the Mooreville (Campanian). However, Hesperornis occurs in the midcontinental Pierre Shale (Campanian). Hesperornis may then be found in the lag deposits of the basal Eutaw Fm. of AL, barring its absence due to difference of depositional environment between the Niobrara and Eutaw Formations. The absence of Hesperornis may also reflect a southern range limit for Hesperornis, known from Kansas north to Canada. Environmental similarities as evidenced by the near match of non-avian fauna from Kansas and Alabama make this unlikely. A very recent find, (Sept. 1992) from Greene Co., AL appears to be undescribed and may represent a new clade. Mooreville avians represent attrition from migration.

THE EFFECTS OF ELEVATED LEVELS OF CARBON DIOXIDE AND NITROGEN ON PHOTOSYNTHESIS OF SWEET POTATO. R.C. Strachan and D.R. Hileman, Dept. of Biology and M. Alemayehu, G. Huluka, J. Moore and P.K. Biswas, Dept of Agricultural Sciences, Tuskegee Univ., Tuskegee, AL 36088

Sweet potato (Ipomea batatas c.v. 'Georgia Jet') plants were exposed to six treatments in a randomized complete block design with four replicate blocks. The treatments consisted of three CO₂ treatments (open-field plot and chambers with 0 and 300 $\mu\text{mol mol}^{-1}$ of CO₂ added to the ambient level) and two nitrogen treatments. Leaf gas exchange measurements were taken when the plants were 51-78 days old using the LI-COR LI-6200 portable photosynthesis system. Gas exchange measurements were performed on six leaves from each plot. Measurements were made between 0900 hours and 1300 hours CST, when the light intensity was above 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$. Photosynthetic rates and water use efficiency were significantly higher while transpiration and stomatal conductance rates were significantly lower in plants grown at elevated CO₂. There was no significant nitrogen effect on photosynthesis, transpiration, stomatal conductance or water use efficiency. The research was supported in part by the Department of Energy (contract No. DE-FG05-86ER-60498) and by the Tuskegee University Agricultural Experiment Station.

Abstracts

APPLICATION OF POLYMERASE CHAIN REACTION (PCR) IN DISTINGUISHING LIVE AND DEAD BACTERIAL CELLS. *Sharon Graves and A. K. Bej. Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294.*

The polymerase chain reaction (PCR) method has been applied to detect various microbial pathogens in clinical, environmental and food samples with high specificity and sensitivity. Since the PCR method uses a unique segment of the genetic material from a target microbial pathogen, concerns have been raised that this method may have the potential to detect dead cells providing false-positive results. To determine the ability of the PCR method to distinguish live from the dead microorganisms, aliquots of an exponentially grown culture of *Salmonella typhimurium* were treated with hypochlorite biocide upto 30 min at 5 min intervals. After terminating the biocide treatment with sodium thiosulfate, aliquots from each sample were exposed to INT to determine the total number of metabolically active cells, stained with acridine orange fluorescent dye for total cell enumeration, and plated onto agar media for total viable plate counts. Also, an aliquot of each of the biocide-treated samples was PCR amplified using LHNS and RHNS oligonucleotide primers. Although viable culturable *S. typhimurium* cells were detectable only after 5 min of biocide treatment on agar plates, the INT and the PCR positive samples were detectable upto 15 min of treatment indicating the presence of viable but non-culturable *S. typhimurium* cells in the samples. At 20 min of biocide treatment, all cells were INT-negative, indicating the presence of dead cells. Also, these INT-negative samples did not show any PCR amplification of the target microorganisms. Therefore, the PCR method specifically detected the viable, and metabolically active live *S. typhimurium* in the samples.

β -GLUCURONIDASE COMPETITIVE INHIBITION FROM HUMAN SYNOVIAL FLUID.
Kedi Wang and Michael E. Friedman, Dept. of Chemistry, Auburn University, AL 36849.

β -Glucuronidase (β -D-glucuronide glucuronohydrolase, (EC 3.2.1.32), an enzyme released in relatively large quantities during joint inflammation, was purified from human synovial fluid by chromatography, yielding a 148 fold purification. The K_M for the substrate phenolphthaleinglucuronide was experimentally determined to be 0.321 mM.

The enzyme was then inhibited by sodium thiomalatoaurate (I) and saccharo 1,4-lactone. Both compounds, the former being a drug commonly used in cases of Rheumatoid Arthritis, and the latter an analog of the naturally occurring substrate, have been shown to be competitive inhibitors. The K_I 's were determined, and a value of 460 μ M was obtained for the gold compound and 215 nM was obtained for the saccharide.

A number of steroids have been used to inhibit this enzyme. One of them, 6-nitrocholesterol, which was found to be of a mixed inhibition type was reasonably effective. Studies have been performed to determine if the steroid is inhibiting at the substrate binding site.

Abstracts

POLYMERASE CHAIN REACTION (PCR) BASED DETECTION OF *Salmonella* spp. IN CHICKEN MEAT. *R. M. Law, A. K. Bej, and D. D. Jones, Department of Biology, Univ. of Alabama at Birmingham, AL 35294-1170.*

The increased prevalence of foodborne microbial pathogens, such as *Salmonella* spp., has heightened concerns about food safety. Consumption of foods such as chicken meat contaminated with *Salmonella* spp. can cause enterocolitis, gastroenteritis, and septicemia. A rapid, reliable, and sensitive method has been developed to detect this pathogen in artificially contaminated chicken meat using PCR DNA amplification. The PCR is a primer-directed, *in vitro* enzymatic amplification of specific target DNA sequences. *S. typhimurium* cells from a freshly grown culture were added to minced chicken meat samples. DNA from the target microbial pathogen was purified by adding a chelating resin, Chelex® 100 to the sample, incubating at 60°C for 15 min with intermittent vortexing, boiling for 10 min, and adding 2.5 M solid NH₄OAc. The treated meat sample was centrifuged and the supernatant transferred to a fresh tube. The supernatant was then extracted with chloroform:isoamyl alcohol, concentrated with a Centricon® 100 microconcentrator, and treated with ProCipitate®, a protein precipitating reagent. Two oligonucleotide primers designed to detect a 152 bp region of the histone binding protein (HNS) in *Salmonella* spp. were used to direct PCR amplification. The amplified DNA was electrophoretically separated and visualized on agarose gels. To confirm the presence of *Salmonella* spp., DNA-DNA hybridization was performed using an oligonucleotide probe internal to the target DNA sequence. This rapid, reliable method of DNA extraction coupled with PCR amplification can be used to detect *Salmonella* spp. and other foodborne microbial pathogens to reduce the risk of disease outbreaks.

THE BURROWING CRAYFISHES (DECAPODA: CAMBARIDAE) OF THE CAHABA RIVER SYSTEM. *James V. Buchanan, Department of Biological Sciences, University of South Alabama, Mobile, AL 36688.*

Few systematic surveys of the crayfishes of Alabama have been conducted. An intensive survey of the burrowing crayfishes of the Cahaba River Basin was undertaken from July, 1991 until March, 1992. A total of 279 localities was surveyed yielding 285 specimens. Fifteen species of fossorial crayfishes representing five genera (Cambarus, Fallicambarus, Hobbsius, Orconectes, and Procambarus) were found. Of the fifteen species encountered, none were endemic to the Cahaba River Basin. Two of the fifteen species represented introductions into the region. The distribution of the various species encountered, their reproductive ecology, habitat preferences, and burrow morphologies are presented. This survey will serve as baseline data by which changes in burrowing crayfish populations in the Cahaba River Basin can be measured.

Abstracts

DETECTION OF *Corynebacterium jeikeium* IN BLOOD BY POLYMERASE CHAIN REACTION (PCR) METHOD. A. J. Perry and A. K. Bej, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294-1170.

Corynebacterium jeikeium has been identified as an etiologic agent for bacterial endocarditis, especially in patients who have had open heart surgery. A detection method using PCR-gene probe was developed for this pathogen because the conventional methods, which are based on the culturing of this pathogen in non-selective followed by selective microbiological media, are unreliable and time consuming. Two oligonucleotide primers, 23 and 24 mer, were designed from the deduced nucleotide sequence of a cloned fragment of the thymidylate synthase (TS) gene from *C. jeikeium*. Using these primers, PCR amplification of the *C. jeikeium* genomic DNA generated a 0.2 kb amplified DNA band during electrophoretic separation. With these primers, 6 isolates of *C. jeikeium* from patient's blood were tested for PCR amplification. No amplification occurred when 8 strains of non-*C. jeikeium* species of *Corynebacterium* and 46 non-*Corynebacterium* bacterial strains were tested confirming the specificity of the primers. The sensitivity of this PCR-based detection was determined by the addition of *C. jeikeium* cells ($\sim 10^6$ - $< 10^1$) to 0.5 ml blood samples. The amplified DNA was detected by an oligonucleotide probe internal to the amplified DNA sequence at a sensitivity of < 10 target *C. jeikeium* cells, in the presence or absence of $> 10^6$ non-target cells. This rapid, reliable, and sensitive detection of *C. jeikeium* in blood takes approximately 8 hours to complete. The PCR-gene probe approach can be useful for routine monitoring and early detection of *C. jeikeium*, and possibly other microbial pathogens in the blood of patients, reducing the risk of bacterial endocarditis.

A PSEUDO-NEWTONIAN GRAVITATIONAL THEORY ARISING FROM ENERGY DENSITY CONSIDERATIONS. J.H. Young, Dept. of Physics, Univ. Al. at B'ham, Birmingham, AL 35294.

General relativity is a theory of gravitation having all of the basic requirements of special relativity built into it. The well known mass-energy equivalence suggests that a complete theory of gravity should include field energy density in addition to mass density as a gravitational source. Incorporating field energy density into Newtonian gravity leads to a nonlinear pseudo-Newtonian gravity [P.C. Peters, *Am. J. Phys.*, 49(6), 564 (1991)] which offers a number of the interesting characteristics of general relativity while avoiding the mathematical complexities of that theory. The basic ideas of this incorporation will be discussed along with several of the immediate physical consequences.

Abstracts

CONTROL OPTIONS FOR ZEBRA MUSSEL INFESTATIONS. Robert F. McMahon, Center for Biological Macrofouling Research, Box 19498, Univ. Texas at Arlington, Arlington, TX 76019.

Options for mitigation/control of zebra mussel (*Dreissena polymorpha*) macrofouling of raw water systems include chemical or nonchemical approaches and off-line or on-line application strategies. Among chemical options, chlorination and a molluscicide formulated from Dimethylbenzyl Ammonium Chloride and Dodecylguanidine Hydrochloride are presently most utilized to control zebra mussel fouling in North America. However, other potentially efficacious molluscicides are available or being developed including: Bromine; Ozone; and several nonoxidizing agents. Toxic paints and coatings are also effective. Among nonchemical technologies, manual removal, line pigs, and thermal treatments are presently most utilized, while robotic cleaners, dewatering and desiccation, exposure to freezing conditions, nontoxic foul-release coatings, strainers, centrifugal separators, infiltration beds, anoxia/hypoxia, and disposable substrata all appear to be important emerging technologies. An effective zebra mussel macrofouling control/mitigation strategy is likely to involve integration of several different technologies fitted to a particular system's specific operating, environmental and regulatory constraints. Regulatory pressure to reduce biocide release into receiving waters is likely to increase over the next decade. Thus, long-term solutions to zebra mussel control should focus on nonchemical technologies.

THE EFFECTS OF SALINITY ON THE DEVELOPMENT AND REPRODUCTION OF THE FRESHWATER SNAIL, HELISSOMA SP.. Alan Whitehead and Anne M. Cusic, Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

Embryos of the freshwater pond snail, Helisoma sp. in the gastrula stage were placed in saline solutions ranging from 1 ppt to 10 ppt with conditional tap water as a control. At 1 ppt, survivorship was 88% control with no effect on growth, development, or reproduction. At 2 ppt, survivorship was 89% with no effect on development or growth; however, adults were unable to produce egg masses that would hatch. At 4 ppt, survivorship was 85% with no significant effect on hatching, but the embryos were slightly smaller in their overall size. At 5 ppt, survivorship was 33% with embryos being somewhat smaller in size. Doses of 6 ppt and 7 ppt produced malformed embryos with a bubble-like sack replacing the calcified shell, none of which hatched. At 10 ppt development did not proceed from the gastrula stage and the embryos died. This preliminary data suggests that there is an inverse relationship of saline concentration and growth and development of Helisoma sp.

Abstracts

SIMPLE REPETITIVE DNA SEQUENCES ASSOCIATED WITH HETEROGAMETIC SEX IN MOSQUITOFISH. *Praful G. Patel, R. A. Angus, and A. K. Bej, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294.*

Many animals have been characterized as having a specific heterogametic sex based solely on chromosome morphology. However, in fishes, a heterogametic sex is difficult to characterize. One particular problem in fishes is that karyotype analysis does not reveal a sex chromosome in most species. In several species of fish, DNA fingerprinting analysis of minisatellite DNA has provided a way to determine the heterogametic sex by hybridization using short tandem [(GATA)_n/(GACA)_n] sequences as probes. Despite success in some families of fish such as Poeciliid, sex heterogamacy cannot be substantiated in even different species within the same family. In a hybridization study using various [(GATA)_n/(GACA)_n] oligonucleotides proved to be sex-specific at higher molecular weight bands in *Poecilia reticulata*. In general, DNA from the fish tissue was released using GITC treatment, purified with phenol-chloroform and concentrated with NH₄OAC, and dialyzed against TE buffer. The DNA was then digested with restriction enzymes for 24 hours, and separated on an agarose gel by electrophoresis. The gel is dried and hybridization was carried out either directly on the dried gel or on a nylon membrane following capillary transfer, using a radio-labeled oligonucleotide probe. Despite success in the use of DNA fingerprinting in other members of the Poeciliid family, no fingerprint has been observed in *Gambusia affinis* (the eastern mosquito fish). Therefore, the DNA fingerprint protocol designed to determine heterogametic sex in fishes using sex specific, tandemly repetitive DNA sequence probes cannot be used universally and requires further modifications.

DEVELOPMENT AND CHARACTERIZATION OF POLYCLONAL ANTISERA AGAINST OVARIAN VITELLIN ISOLATED FROM THE BLUE CRAB, CALLINECTES SAPIDUS. Chi-Ying Lee and R. Douglas Watson, University of Alabama at Birmingham, Birmingham, AL 35294-1170.

Polyclonal antibodies were raised in rabbits against vitellin (Vn), the major egg yolk protein, purified from the ovary of a vitellogenic blue crab, Callinectes sapidus. Several immunological methods were utilized to characterize the antiserum. In slot blot analyses, the antiserum reacted with the ovarian homogenate from which Vn was isolated, whereas control preimmune serum showed no reaction with the same homogenate. The antiserum was also tested in a double immunodiffusion test. Single precipitation lines were found between the center well containing immune serum and the surrounding wells containing, respectively, purified Vn, purified vitellogenin (Vg, the hemolymph precursor of Vn), female hemolymph and ovarian homogenate. The precipitation lines are continuous with each other indicating the antiserum recognizes proteins of complete identity. Neither Vn, Vg nor any of the tissue homogenates precipitated with the preimmune serum. Finally, a Western blot analysis revealed that the antiserum bound to both Vn and Vg. We anticipate utilizing this antiserum to develop immunoassays for investigating the hormonal and environmental control of yolk protein synthesis.

Abstracts

POLYCULTURE OF THE PULMONATE GASTROPOD *PHYSELLA CUBENSIS* AND THE AUSTRALIAN CRAYFISH *CHERAX QUADRICARINATUS* IN A CLOSED, INDOOR RECIRCULATING SYSTEM. D.L. Thomas, M.E. Meade and S.A. Watts, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294-1170.

The common Alabama pulmonate snail *Physella cubensis* can be cultured in biofilters receiving effluent from closed, recirculating systems used for culture of the Australian crayfish, *Cherax quadricarinatus*. The snails were cultured in flat, 0.36 m² box filters containing hogshair and oyster shell hatch as the bacterial matrix. Each filter received recirculated effluent from a 1.44 m raceway containing 15 to 20 adult *C. quadricarinatus*. Growth of *P. cubensis* from hatchling to adult occurred more rapidly in this system than in finger bowl culture (13 vs. 18 days, respectively) at 27°C. The snails were able to grow and reproduce at optimal levels in the biofilters subsisting entirely on bacterial film. Feeding activity helped to prevent the overgrowth of bacteria which must be periodically removed from the biofilter in the absence of the snails. In addition to their contribution to filter maintenance, *P. cubensis* may be useful as a supplementary food source for *C. quadricarinatus*. Adult *C. quadricarinatus* cultured in the laboratory feed readily on the snails, which are known to constitute an important natural food source for many Alabama crayfish species. The co-culture of *P. cubensis* with crayfish might prove a useful means of providing a year-round source of *P. cubensis* for gastropod research as well as a nutritional supplement for the crayfish at minimal cost.

CAN A HERBIVORE GENERALIST BE AN OPPORTUNISTIC CARNIVORE?
Michael Kay and James B. McClintock, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294-1170.

The regular sea urchin *Lytechinus variegatus* is classically considered to be herbivorous, feeding on a variety of algae and sea grasses. Although plant foods may be more abundant and predictable foods than animal prey, plants are lower in nutrients and energy. Therefore, one might predict that herbivores such as *L. variegatus* should feed opportunistically on animal prey when readily accessible. We tested the hypothesis that *L. variegatus* will prefer animal food when given a choice between plant and animal food models. In one experiment, sea urchins were presented one of two diets comprised of either agar food models containing a 5% concentration of a plant or animal based meal. Sea urchins consumed significantly more animal than plant food during each of eight weeks. In a second experiment, sea urchins were given a choice of foods by placing each individual on two food models, one animal and one plant. Sea urchins showed a highly significant preference for animal foods, rarely consuming plant food. These experiments suggest that *L. variegatus* may feed opportunistically on animal prey in their natural environment. This hypothesis is indirectly supported by studies of the gut contents of *L. variegatus*, several of which indicate that these sea urchins may consume small crustaceans, gastropods, sponges and polychaetes in addition to plant foods.

Abstracts

POPULATION ECOLOGY OF THE SOUTHERN FLYING SQUIRREL (GLAUCOMYS VOLANS) IN ALABAMA. Suzie Hatten, David Nelson and Dwayne Biggs, Dept. of Biology, Univ. of South Alabama, Mobile, AL 36688.

A 12-month study of the natural history and population dynamics of Glaucomys volans was conducted in Mobile County, Alabama. One hundred nest boxes were installed in a grid system with 25-m intervals. In addition, 68 live traps were installed such that each trap was centered within 4 nest boxes. Nest boxes were checked bimonthly, and trapping was conducted for five consecutive days at the end of each month. From June 1991 through May 1992, 64 squirrels were captured 497 times. Two hundred and ninety one captures (59%) occurred in nest boxes while 206 captures (41%) occurred in traps. Overall, 45 of the nest boxes were used solely as nesting sites, 12 as feeding stations, one as a defecatorium and eight exhibited changing use. Mean adult home range size was 0.82 ha (males = 0.94 ha and females = 0.68 ha). Mean juvenile home range size was 0.38 ha (males = 0.41 ha and females = 0.32 ha). Home ranges of adult males showed considerable overlap and were clustered in an area of low female density. Home ranges of adult females overlapped much less. The mean density of flying squirrels was 3.48 squirrels/ha. The largest aggregations (N = 9 squirrels) were found in December and February. Males were found to have two distinct reproductive periods. Most males were in full reproductive condition from early May through July and from mid-November through early January. Seven litters were discovered in nest boxes. Six of these were born in late August (mean litter size = 3.3) while one litter of two was born in mid-February.

ECOLOGICAL IMPACTS OF ZEBRA MUSSELS IN THE GREAT LAKES AND SPREAD IN NORTH AMERICA. Don W. Schloesser. U.S. Fish & Wildlife Service, Ann Arbor, MI 48105 and Kenneth M. Muth. U.S. Fish & Wildlife Service, Sandusky, OH 44870.

Zebra mussels (Dreissena polymorpha) were discovered in North America in 1988 and are believed to have been introduced via the discharge of ship ballast water in Lake St.Clair of the Laurentian Great Lakes in 1986. In 1989, zebra mussels began exponential reproduction and reached a maximum density of 750,000/m² in portions of western Lake Erie, causing serious problems for raw water users and raising major concern for the ecology of aquatic systems. Observed ecological impacts in western Lake Erie that have been attributed to zebra mussels include: increased water clarity, reduced plankton populations, reduced total water column chlorophyll, increased substrate heterogeneity, changed benthos populations, and, the most dramatic impact, reduced unionid populations (in open waters of western Lake Erie, and nearby water bodies, unionids have been or are being extirpated due to zebra mussels). Concern about food web structures has lead to studies into the potential impact on fishes. The present and projected range of zebra mussels (and similar mussels known as "quaggas") in North America indicate that ecological impacts similar to those being observed in western Lake Erie are likely to occur in surface waters throughout a large portion of the United States.

Abstracts

CHEMICAL COMMUNICATION AND POPULATION STRUCTURE OF ECHINODERMS IN MARINE COMMUNITIES: ROLE OF STEROIDS.

Stephen A. Watts, Gene A. Hines, James B. McClintock and Ken R. Marion,
Dept. of Biology, UAB, Birmingham, AL 35294-1170. Thomas S. Hopkins, Dept.
of Biol. Sciences, Univ. of Ala., Tuscaloosa, AL 35487-0344.

Echinoderms represent one of the most prominent groups of benthic invertebrates in the marine environment. Their abundance in shallow and deep water communities can have a highly significant impact on community structure. Understanding echinoderm intra- and interspecies chemical communication will increase our knowledge of processes which influence community structure in marine ecosystems. We are investigating the production and influence of hormones and steroid pheromones from echinoderms in the northern Gulf of Mexico. These echinoderms produce a variety of steroid products that are, in some cases, homologous to those found in vertebrates, including testosterone, dihydrotestosterone, androstane derivatives, and estrone. The metabolic pathways used to produce these compounds are similar to those found in vertebrates. The types and quantities of steroids produced depend on the tissue type and the reproductive state of the organism. Several echinoderm species produced large quantities of water-soluble steroid conjugates, primarily glucuronides, which may have pheromonal activity. Preliminary results suggest that other echinoderms produce 11-oxy androgens which were previously found only in fish, suggesting a close evolutionary relationship among these groups. These steroids and steroid-related compounds present in echinoderm tissues may function as chemical signals which regulate physiological processes within individuals and influence both intra- and interspecific chemical communication. Supported by NSF EPSCoR grant EHR 9108761.

Characterization of a New Isolate of Toxoplasma gondii from the Alabama Bobcat. R.S. VAN HOUTEN, C.A. SUNDERMANN, D.S. LINDSAY* & E.E. WESTER. Department of Zoology & Wildlife Science, *College of Veterinary Medicine, Auburn University, AL 36849.

Toxoplasma gondii was isolated from thigh and heart muscle of an adult male bobcat, Lynx rufus, collected in Lee Co., Alabama. This new isolate has been designated BC - 1. Mice inoculated subcutaneously with digest of this tissue developed tissue cysts. Cysts from fresh brain smears ranged from 21 - 132 μm in diameter ($n = 27$; mean = 65.3 μm). Zoites harvested from these cysts were inoculated onto monolayers of human fetal lung (HFL) cells. Tissue cysts developed in the HFL cells and were processed for transmission electron microscopy. Cyst wall thickness ranged from 0.125 - 0.33 μm . Ultrastructure of the zoite apical complex revealed the presence of rhoptries with a spongy appearance, micronemes, polar rings, subpellicular microtubules (number = 22), and a conoid. Micropores, amylopectin granules, nuclei and a grainy or particulate tissue cyst wall were also noted. This is the first report on the ultrastructure of T. gondii isolated from a bobcat. Supported by the Alabama Agricultural Experiment Station.

Abstracts

UBIQUITINATED YOLK PROTEINS IN INSECTS. Susila Dorai-Raj and Jim Bradley. Dept. of Zoology and Wildlife, Auburn University, 36849.

Ubiquitin (Ub) is a highly conserved 8.6 kD polypeptide that becomes covalently conjugated to intracellular proteins, thereby marking them for an energy dependent proteolysis. In the house cricket, Acheta domesticus, and the stick insect, Carausius morosus, vitellin (VN) polypeptides undergo a developmentally programmed pattern of proteolysis during oogenesis and/or embryogenesis. We have tested the reactivity of VN and VN-derived polypeptides with anti-Ub (Sigma Chem.) by Western blotting. In Acheta, anti-Ub reacted with a single 49kD VN polypeptide (YP IV) in chorionated eggs and its corresponding vitellogenin (VG) polypeptide in the hemolymph. Similarly, a 50 kD yolk polypeptide (A3'), the processed form of 60 kD VN polypeptide A3, in chorionated eggs of Carausius was reactive. A 70 kD polypeptide was the sole reactive species in unchorionated follicles. Examination of embryos from oviposition through hatching in both species showed that A3' and YPIV remain reactive throughout embryogenesis. The intensity of YP IV reactivity in Acheta decreased during embryogenesis, whereas that of A3' in Carausius remained constant. Free Ub competed with both polypeptides for reaction with anti-Ub. Sigma anti-Ub was also found to react with a 50 kD polypeptide in the ovary of the grasshopper, Pardalophora phoenicoptera. A rabbit polyclonal antiserum against free Ub (Sigma) was prepared and shown to be reactive with free Ub and Carausius polypeptide A3' but unreactive with Acheta and Pardalophora yolk proteins. Supported by the Alabama NSF-EPSCoR Program in Molecular, Cellular and Developmental Biology (Grant #RII-8610669) and HATCH Project 665 (AAES).

NEST-SITE SELECTION, NEST CONSTRUCTION AND NEST ENTRANCE ORIENTATION IN THE BACHMAN'S SPARROW (*AIMOPHILA AESTIVALIS*). Thomas M. Haggerty, Department of Biology, Univ. of North Alabama, Florence, AL 35632-0001

In pine plantations in central Arkansas from 1983-1985, the macrohabitat of Bachman's Sparrow (*Aimophila aestivalis*) nest sites could best be discriminated from nonnesting sites by percent forb cover, percent woody cover, and shrub density. Canonical discriminant analysis of macrohabitat variables showed that nest-sites were associated with greater tree and shrub densities, higher trees and woody vegetation, but with less forb cover, woody cover, vertical vegetation density between 0 - 90 and 0 - 180 cm, and lower forb height than random sites. Nest sides had greater vegetation density between 0 - 60 and 0 - 180 cm, and greater woody cover than random points and nest entrances. Most nests were partially (38%) or completely domed (55%) and entrances were oriented in a northern direction. Nest construction was not affected by degree of concealment, nesting year, or nesting season, but grasses and forbs were taller around domed nests than at partially domed nests. Nest success was not affected by degree of concealment or macrohabitat structure.

Abstracts

DOES THE PORTUNID CRAB SPECIES CALLINECTES SIMILIS IONICALLY RUN IN PLACE IN THE OSMOREGULATORY RACE WITH C. SAPIDUS?

Sabine C. Piller, Jeannette E. Doeller, and David W. Kraus. University of Alabama at Birmingham, Dept. of Biology, Birmingham, AL 35294

The two portunid crab species Callinectes sapidus and C. similis inhabit Alabama's estuaries. Their distribution in the Gulf of Mexico is correlated to salinity. Both species co-occur above 15‰ salinity, but C. similis is rarely found below 15‰ salinity. At low salinities, both species maintain their hemolymph more concentrated than the ambient seawater by actively pumping ions into their hemolymph. This ion-pumping process primarily takes place in the posterior gills and requires energy in the form of ATP. ATP is mainly produced during oxidative phosphorylation in the mitochondria. To compare osmoregulatory capabilities between the two species, we measured mitochondrial function in excised intact posterior gills as a function of salinity. Mitochondrial function was measured as oxygen consumption rate, pO_2 at which oxygen consumption rate was half maximal (p_{50}), and mitochondrial density. Additionally, hemolymph osmolality and hemolymph Na^+ , K^+ , and Cl^- concentrations were measured as a function of acclimation salinity. In both species, oxygen consumption rate and mitochondrial density increased significantly as salinity decreased, while p_{50} 's did not change significantly. The increase in oxygen consumption rate and mitochondrial density was significantly greater in C. similis gills than in C. sapidus gills. This suggests that both species increase the number of mitochondria in posterior gills as a response to low salinities, but C. similis does so to a greater extent. Despite the higher metabolism observed in C. similis gills, C. similis could not maintain its hemolymph as concentrated as that of C. sapidus. Therefore we suggest that the gills of C. similis may be more leaky to ions than those of C. sapidus. Supported in part by grants from the BMFWF, Austria and AAS to SCP and NSF IBN9118048 to JED and DWK.

ZEBRA MUSSELS IN THE TENNESSEE VALLEY: CURRENT SITUATION AND PROGNOSIS
Steven A. Ahlstedt, Wat. Mgmt., Aquatic Biol. Dept., Tennessee Valley Authority, Norris, TN 37828.

The zebra mussel, Dreissena polymorpha, was first discovered by commercial musselers in the lower Tennessee River at river mile 30 (Kentucky Lake) in September 1991. The mussel has since spread upstream and has now reached Nickajack Lock and Dam at river mile 425 near Chattanooga, Tennessee. Predictions are that it will rapidly become established in all suitable habitats from the extreme southern U. S. to central Canada. At present, zebra mussels have been reported in numbers ranging from a few to over a thousand individuals on navigation lock walls and miter seals. Commercial musselers are routinely finding zebra mussels as single specimens attached to native mussels. Zebra mussels have killed all mussel species in portions of the Great Lakes. Because of ideal growing conditions, water quality, and food availability for native mussel species in southern rivers, conditions appear optimum for the rapid spread and colonization of zebra mussels.

Abstracts

COMPARISON OF REFERENCE STREAMS BETWEEN ECOREGIONS USING RAPID BIOASSESSMENT PROTOCOLS. Phillip Emmert and E. Cliff Webber, Dept. of Fisheries, Auburn University.

Reference streams were sampled in Spring 1992 from two subregions: the Piedmont subregion of the Southeastern Plains ecoregion located in east-central Alabama and the eastern subregion of the Southwestern Appalachian ecoregion located in central Alabama. U.S. EPA Rapid Bioassessment Protocols (RBP) were used to assess stream quality. RBP is an integrated assessment comparing habitat (eg. physical structure and flow regime) and biological measures with empirically defined reference conditions within an ecoregion. Reference streams are defined as the "best attainable conditions" against which other streams are compared when assessing impacts. EPA and The Alabama Department of Environmental Management (ADEM) have now suggested using reference streams within subregions of the ecoregion. We compared the inter and intra-variability of two reference streams within each of two subregions defined by EPA. No distinct differences were evident between subregions. The two streams in the eastern subregion of the Southwestern Appalachian ecoregion exhibited distinct differences. Observations revealed heavily forested watersheds but some clear cutting was evident on one of the streams. The two streams in the Piedmont subregion had similar stream quality. Land use within the watersheds of the Piedmont streams was comprised of more pasture and less forested land than the Southwestern Appalachian watersheds. Therefore, land-use patterns appeared to be a major factor influencing variability among reference streams.

REPRODUCTIVE BIOLOGY OF QUADRULA METANEVRA (UNIONIDAE) IN KENTUCKY LAKE. Jeffrey T. Garner, Aquatic Resources Center, Franklin, TN, and Richard F. Modlin, University of Alabama in Huntsville, Huntsville, AL.

The reproductive biology of Quadrula metanevra in the Tennessee River, Hardin Co., Tennessee, was investigated over a period of two years (July 1988 to June 1990). Histological preparations of gonadal tissue were used in the assessment. Gonadal tissue of both sexes remained active throughout the year, though activity decreased during the winter months. Spawning began during the winter and continued through mid July. Mature glochidia were found in the marsupia of females from March to late July. The sex ratio of the population was 1.45:1 (females to males). Hermaphroditic individuals made up 1.8% of the population. All hermaphrodites appeared to be functionally male.

Abstracts

TUMOR NECROSIS FACTOR (TNF): RECENT ADVANCES. Richard E. Jones and Robert E. Pieroni, Dept. of Internal Medicine, Univ. of Ala., Tuscaloosa, AL 35487.

Tumor necrosis factor (TNF) was initially described as a macrophage-derived protein which could induce the hemorrhagic necrosis of certain types of tumor cells in immunologically-primed mice. TNF is now known to represent two activities, specifically, TNF-a or cachectin, and the unique but structurally similar TNF-B, or lymphotoxin (LT). As implied by its name, TNF-a/cachectin has been identified as a central etiologic agent of the "wasting" phenomenon known to occur in subjects with overwhelming sepsis or malignant disease. More recently, the broad role of TNF-a as a pyrogen, acute phase reactant, and as a mediator of pathologic inflammatory disease has been investigated. Data suggest that synthesis and secretion of this factor may play a role in autoimmune states, such as rheumatoid arthritis and multiple sclerosis. Receptors for TNF-a have been identified on many cell types, ranging from T cells to vascular endothelium. TNF-a has specifically been shown to be a potent in vitro promotor of cytotoxic activity by granulocytes. Current data indicate that an immunologic regulatory network exists between TNF-a, TNF-B, IL-1, and other cytokines which, when acting upon various cellular components of the immune system, may lead to autoimmune disease. This review indicates that TNF-a plays a central role in the regulatory cascade of both normal and pathologic immune functions.

OPTIMIZATION OF GROWTH IN HATCHLING AUSTRALIAN CRAYFISH, *Cherax quadricarinatus*: A COMPARISON OF COMMERCIAL FEEDS. Mark E. Meade and Stephen A. Watts. Univ. of Ala. at Birmingham, UAB Station, Birmingham, AL 35294.

The success of the commercial production of the Australian freshwater crayfish, *Cherax quadricarinatus*, in the Southeastern US depends largely on the ability of producers to maintain hatchlings indoors during the cooler months of the year. During this indoor season, hatchling growth must be maintained in preparation for pond grow-out. We examined the growth and survival of hatchlings held indoors fed different commercial feeds to determine a suitable and costly-feasible diet which could be used in an indoor hatchery system. A total of 32 hatchlings from 7 different females were used in each diet treatment. All diets were pulverized and introduced to hatchlings in a 2% agar binder. Several commercial feeds were evaluated including Argent's Brine Shrimp Flakes, Freeze-dried Krill, Powdered Spirulina, and Hatchfry Encapsulon. After two weeks, hatchlings fed any of these Argent feeds demonstrated little or no growth and mortality was high (> 90%). After 10 weeks of growth, hatchling crayfish fed Zeigler post-larval shrimp feed averaged 270 mg (± 159.5 SD) fresh weight with only 41% survival. Those hatchlings fed Zeigler shrimp grower averaged 323 mg (± 170 SD) fresh weight with slightly improved survival of 66%. Hatchlings fed Burris Mills crayfish feed averaged 290 mg (± 159.5 SD) fresh weight with a survival of 72%. Hatchlings fed a newly formulated UAB hatchling feed demonstrated the best survival and growth, averaging 448 mg (± 247.4 SD) fresh weight with 91% survival at 10 weeks ($p < .05$). In all diet treatments, considerable differences in growth rates were observed among female hatches suggesting qualitative differences among offspring of brood females. We hypothesize that with further refinement, our UAB feed can be successfully used for the grow-out of hatchling crayfish in indoor facilities.

Abstracts

ISOELECTRIC FOCUSING OF TOTAL PROTEINS IN COMMERCIALY CULTURED CRAYFISH SPECIES. Mickie L. Powell, Mark E. Meade, and Stephen A. Watts, Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

Total proteins in the tail muscle of Procambarus clarkii, P. zonangulus, and Cherax quadricarinatus were separated based on their pl values using isoelectric focusing (IEF). Samples were separated using hand-poured 4.5% polyacrylamide gels and commercially available IEF polyacrylamide gels from LKB/Pharmacia. Tail muscle was removed from freshly killed crayfish, divided into several aliquots, and stored at -70°C until the proteins were extracted. Proteins were extracted from the tissue using several different methods including extraction in water on ice, in boiling water for 10 min, in 8M urea, and using phenol/chloroform. For all preparations, the initial separation of proteins on broad pH range gels (pH 3-10) showed the largest concentrations of protein bands occurred in the acidic pH range (pH 4-6.5). The banding patterns present in the acidic region were slightly different depending on the protein extraction method used. Denaturing the samples using heat or urea eliminated several protein bands that had been observed in the cold water preparation. The urea extraction increased the number of visible protein bands, but required the presence of urea in the gel. Although banding patterns produced by the phenol/chloroform preparation were easily resolved with little background staining, it was also the most labor intensive preparation and it required greater amounts of tissue. The most time efficient protein extraction that produced a reasonably clear banding pattern was the cold water preparation. Most of the sample preparations produced banding patterns that were species specific and may be used potentially to identify the species.

OBSERVATIONS ON THE REPRODUCTION AND POPULATION BIOLOGY OF AN ANTARCTIC BROODING SEA CUCUMBER (*Cucumaria ferrari*). Brian K. Gaschen, James B. McClintock and Marc Slattery, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294-1170 and John Heine, Moss Landing Marine Laboratories, CA 95039.

Little information is available on the reproductive mode and population biology of antarctic sea cucumbers. Individuals of *Cucumaria ferrari* were collected using Scuba under the seasonal pack ice from 30 m depth near Hut Point, McMurdo Sound, Antarctica. The mean density (± 1 S.D.) of sea cucumbers collected from three 0.25 m^2 quadrats within a dense assemblage of branching hydrozoans (*Haleciump* sp.) was 42.6 ± 26.5 . Individuals ranged in retracted body length and wet wt from 4-66 mm and 0.003-25.15 g, respectively. Size frequency analysis of a population sampled in Nov, 1992, indicated most sea cucumbers were quite small, with 52% of the individuals ranging from 3-10 mm in retracted body length. At least four age cohorts were evident from the population sample. Observations revealed that sexually mature females had large eggs (2 mm diameter) and brooded their young in three body wall chambers immediately posterior to the oral opening. As many as 100 brooded young were collected from a single female, ranging in size from 3.3-4.8 mm length. These data support earlier hypotheses that some antarctic marine invertebrates tend to favor brood protection. Supported by NSF grant # DPP-9118864 to J.B.M.

Abstracts

PREY ELECTIVITY IN THE SEA STAR *ASTROPECTEN ARTICULATUS*.
Steven D. Beddingfield and James B. McClintock, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, AL. 35294. Thomas S. Hopkins, Dept. of Biological Sciences, Univ. of Alabama, Tuscaloosa, AL 35487.

Natural prey species for *A. articulatus* have been documented from several areas within their geographic range. It has been suggested that *A. articulatus* is a non-selective feeder and that its stomach contents reflect the composition of the benthic fauna of the area in which it is found. Nonetheless, no studies have investigated prey electivity in this sea star. This was investigated in *A. articulatus* by identifying prey types found in stomach contents of individuals collected from two sites in the northern Gulf of Mexico, and comparing these prey with fauna found in the surrounding soft sediment. Prey electivity indices were calculated by determining the relative frequency of each organism in the diet and comparing it with the relative frequency of this item in the environment. *A. articulatus* showed positive electivity for several taxa of crustaceans and mollusks. Sea stars exhibited negative electivity values for polychaetes, scaphopods and foramanifera, even though these groups were among the most abundant at the study sites. We gratefully acknowledge the help of the staff of the Dauphin Island Sea Laboratory and the crew of the *R.V. Verrill*. This research was supported by a NSF EPSCoR grant to J.B. McClintock (#R11-8996152) and by the Department of Biology at the University of Alabama at Birmingham.

TEMPORARY POND OLIGOCHAETES, Marianne C. Eckroth and Richard F. Modlin, Department of Biological Sciences, The University of Alabama in Huntsville, Huntsville, AL 35899.

Oligochaeta, aquatic Annelids, were collected from the WEUP Temporary Pond in Huntsville, Alabama, from 1983 through 1987. This community was composed of the following: Varichaetadrilus fulleri, previously reported only from Kentucky and Louisiana, Varichaetadrilus angustepenis, an uncommon species reported east of the Mississippi River and east of Manitoba, Quistadrilus multisetosus, from eastern North America and British Columbia, two species of immature tubificids, and one undescribed species in the Lumbriculidae. With the possible exception of the immature tubificids, the two families and four genera represented have not been previously reported in Alabama. The temporal distribution of the oligochates will be discussed and contributions to their ecology will be presented.

Abstracts

RECOVERY OF GAMETOGENIC ACTIVITY FOLLOWING NUTRIENT DEPRIVATION IN THE ECHINOID LYTECHINUS VARIEGATUS LAMARCK. C.D. Bishop and S.A. Watts, Dept. of Biology, UAB. Birmingham, AL 35294.

Previously starved Lytechinus variegatus were fed a 5% fish meal-sea weed-agar diet for 32 days at 200°C and 32 ppt salinity. Gonadal indices increased significantly by 960% and 303% in females and males, respectively, with most of the growth occurring after day 8. Histological examination of the female gametic tissue revealed the presence of previously developed oocytes but no definable germinal epithelium until day 16. Mean oocyte diameter increased significantly within the first 8 days. At day 16 small zones of germinal epithelium appeared, by day 32 a thickened germinal epithelium and new developing oocytes were observed.

Histology of the male spermatogenic sac suggested an immediate differentiation of all existing spermatocytes and spermatids to mature spermatozoa. No new definable germinal epithelium could be observed until day 16 when thin discontinuous zones appeared. By day 32 thick continuous zones of germinal epithelium were evident.

The trends observed in this study suggest that both sexes utilize a similar two phase strategy in gamete recovery. First an immediate completion to the development/differentiation of existing gametes allowing individuals to attain some minimal reproductive capacity. If unlimited food supplies are available, the second phase of this strategy (initiating the development of a new cohort of gametes) would allow maximal reproductive effort to be attained.

EFFECTS OF GRAVITATIONAL FIELD ENERGY DENSITY AND SOLAR OBLATENESS ON PERIHELION ADVANCES. David C. Patton and J.H. Young, Dept. of Physics, Univ. Al. at B'ham, Birmingham, AL 35294.

The nonlinear pseudo-Newtonian gravitational potential for an oblate mass includes the energy density of that mass as an additional gravitational source. The Kepler problem has been investigated using this modified source and a perihelion advance has been found to result from the oblateness and energy density effects. The use of numerical data appropriate to Mercury in the resulting perihelion shift indicates the significance of including the energy density as a source contribution, although that inclusion alone does not yield a full realization of the perihelion shift of general relativity.

Abstracts

CONSERVATION STATUS OF THE GULF RED PITCHER PLANT, Sarracenia rubra subsp. gulfensis. John D. Wigginton and George W. Folkerts, Department of Zoology, Auburn University, Auburn, AL 36849.

Sarracenia rubra gulfensis, described by Schnell (1979), is one of five subspecies of the red pitcher plant. As presently known, the range of the gulf red pitcher plant extends from southeastern Santa Rosa Co., FL, north to southwestern Covington Co., AL, and east to southwestern Walton Co., FL. There is one possible outlier population in Bay Co., FL. Totally, there are 112 known localities harboring a total of about 26,000 clumps of the plant. Total site area is approximately 250 acres with a mean site size of 2.2 acres. Factors that have been detrimental to the survival of this taxon include drainage, heavy machinery damage during timber harvesting, road construction, pine monoculture, fire restriction, farm pond construction, and development.

PRELIMINARY OBSERVATIONS ON PLANT ACTION POTENTIALS. Richard G. Lee, M. Stanfield, P. Jacobsen, C. Olander, Dept of Biology, Jacksonville State University, Jacksonville, AL 36265.

Using a common variety of Peperomia, action potentials were obtained in the stem after leaf wounding and electrical stimulation. Mean values of the amplitude and conduction velocities in response to nondamaging electrical stimuli have been determined. Data typically obtained will be presented. Amplitudes were essentially identical but the velocity of propagation was greater in the upper than in the lower half of the plant. It was noted that the excitability level between similar plants on the same day and in the same plant on different days is variable and undergoes periodic diurnal changes.

TEACHING SCIENCE IN "INCLUDED" SETTINGS. Joseph D. George, Counseling and Clinical Programs, and Ernest D. Riggsby, Curriculum and Instruction, Columbus College, Columbus, Georgia 31907.

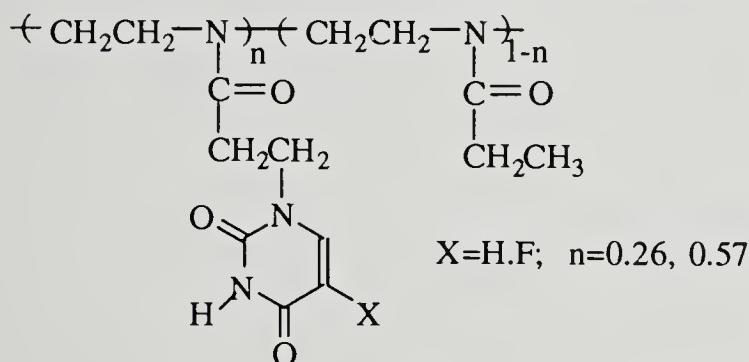
"Inclusion" refers to an instructional setting in which children with special needs and children with disabilities are taught in regular education classrooms alongside gifted and "normal" children. To date, science teachers have had little responsibility for education of children with special needs and children with disabilities. "Inclusion" will change this. It is here to stay. Science teachers at all levels of public schooling will be functioning in "included" settings.

Abstracts

CHEMISTRY

HYPOCHROMICITY OF URACIL- AND 5-FLUOROURACIL-CONTAINING POLYNUCLEOTIDE ANALOGS. Xinhua Chen, Virginia M. Mitchell and Adriane G. Ludwick, Chemistry Department, Tuskegee University, Tuskegee, AL 36088.

Water soluble uracil and 5-fluorouracil containing polynucleotide analogs have been prepared by using 26% and 57% partially hydrolyzed polyethyloxazoline. In order



to examine the nucleic acid character of these analogs by means of hypochromicity, related monomer and dimer models have been synthesized. All the compounds have been characterized by NMR (^1H and ^{13}C) and elemental analyses. Initial screening of the monomer and dimer models selected by NCI were inactive in anticancer and AIDS antiviral assays. For solvents used (water and basic aqueous solutions), significant hypochromicity is observed. The 26% grafted analogs in these solvents indicated higher hypochromicity and better solubility than 57% grafted analogs. (Supported by NIH/MBRS, Grant No. S06GM08091.)

THE PREDICTION OF THE ^{19}F NMR SPECTRA OF AROMATIC COMPOUNDS USING STATISTICAL METHODS. Jimmy R. Nanney, Department of Mathematics, Auburn University at Montgomery, Montgomery, AL 36117-3596 and Christopher A.L. Mahaffy, Department of Chemistry, Auburn University at Montgomery, Montgomery, AL 36117-3596, USA.

Two methods for the prediction of the ^{19}F NMR spectra of fluoroaromatic compounds will be discussed and compared. The first uses a Mathematical Modelling approach in which signal is predicted from an equation written in terms of the position of the group(s) (relative to the fluorine atom) and the Field, \mathcal{F} and Resonance, \mathcal{R} Parameters, the Molar Refractivity and Charlton's Steric Parameter, ν for the group(s) in question. The correlation coefficient for the predicted versus observed values was 0.99 with an average error of prediction of 2 ppm. The second method involves the use of Substituent Chemical Shift values which have been determined statistically. Over 400 of these 'Statistical' SCS (SSCS values) have been determined. When they are used to predict the signal positions, they give a correlation coefficient for the predicted versus observed values of .995 with standard deviation of 2.46. The use of this new method will be described for derivatives of fluorobenzene and fluoropyridine.

Abstracts

THE REAL HAZARDS OF U-238 SERIES OF ELEMENTS. Carlton D. Whitt, 601 Schilling Street, Athens, AL 35611-2931. Retired, TVA, Monsanto.

Some governmental agencies consider U-238 and it's 14 daughters great nuclear threats to man, particularly Rn-222 which is a heavy inert gas. U-238 with a $T_{\frac{1}{2}}$ of 4.51 billion yrs. has 14 daughters each forming at this rate and the daughters formed react at their own $T_{\frac{1}{2}}$. This permits calculations of the maximum amounts of each daughter per gram of uranium. Any radioactive element with a $T_{\frac{1}{2}}$ of a billion years or more is no real nuclear threat to man. U-238 series are all toxic and very poisonous to man but not nuclear hazards. Tritium, H-3, $T_{\frac{1}{2}}$ of 12.26 yrs. and it's product He-3 are not toxic to man but tritium is a great nuclear hazard to man. Just 3 grams of tritium will give as many disintegrations per second as 96,300 tons of U-238 or 6,883 tons of uranium including all it's daughters. The volume of radon $T_{\frac{1}{2}}$ 3.82 days in a 13.1 ft. column of air over a square mile area at 4,000 pCi per liter is only 0.03 ml. and THIS IS A HAZARD?? Too many of our scientists consider alpha emissions worse than beta emissions, but this is true only if the reactions take place inside our bodies. The author has spent a few hundred hours in labs and rooms to which a 50,000 pCi beam of alpha emissions was continuously added not enclosed in any equipment. Nuclear dangers to man come not from naturally occurring sources but from what man and his nuclear technology have done and are still doing. Some chemical hazards will be mentioned such as dioxin, DDT, tricresyl phosphate, L-tryptophan, metal organic compounds, Elixir of Sulfanilamide and carbon monoxide. Some errors made by environmental scientists will be pointed out and explained.

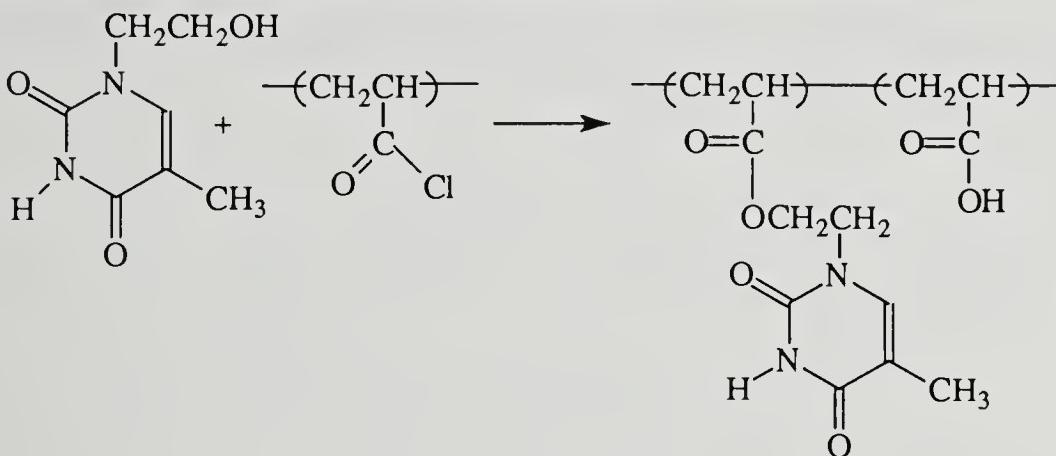
USE OF R_2AlH TO PREPARE Al-N, Al-P, AND Al-As COMPOUNDS. Steven Schauer, C. Lagrone, C. Watkins, and L. Krannich, Dept. of Chemistry, Univ. of AL at Birmingham, Birmingham, AL 35294.

The most commonly used method for synthesizing Al-N, Al-P, and Al-As bonded ring compounds has been the direct reaction between an organoalane, R_3Al , and a secondary organopnictide that leads to a 1,2-elimination process -- elimination of an alkane. Several phosphinoalanes and one arsinoalane have also been synthesized by a coupling reaction/salt elimination methodology. From our study of the reactivity of Me_2AlH with Me_2AsNMe_2 , we have established that $[Me_2AlNMe_2]_2$ forms when the Me_2AlH/Me_2AsNMe_2 stoichiometry is 1:1 and $[Me_2AlAsMe_2]_3$ also forms when it is 2:1. Solution NMR studies on Me_2AlH/Me_2AsNMe_2 and Me_2AlH/Me_2PNMe_2 systems suggested a methodology for the synthesis of Al-P and Al-As ring compounds from $R_2AlH/R'_2MMR'_2$ ($M = P, As$) systems. This has led to the successful synthesis of $[Me_2AlAsMe_2]_3$, $[Me_2AlPMe_2]_3$ and $[Bu^2AlPMe_2]_3$. We have also synthesized ring compounds from the reactivity of R_2AlH with R'_2AsH and R'_2NH . These results and structural data will be discussed and compared with the literature.

Abstracts

THE SYNTHESIS AND CHARACTERIZATION OF A POLYNUCLEOTIDE ANALOG FROM HYDROXYETHYLTHYMINE AND POLY(ACRYLYL CHLORIDE). Eva Graham, Adriane G. Ludwick and Milton Mathis, Chemistry Department, Tuskegee University, Tuskegee, Alabama 36088.

A polynucleotide analog (1) has been synthesized from the reaction of



hydroxyethylthymine (HET) and poly(acrylyl chloride). The analog has been characterized by means of proton and ^{13}C NMR, and infrared spectroscopy. Other methods of analysis include thin layer chromatography, titration and viscosity. Biocompatibility and activity as an antiviral, antitumor agent. will be tested. (Supported by NIH/MBRS, Grant No. S06GM08091.)

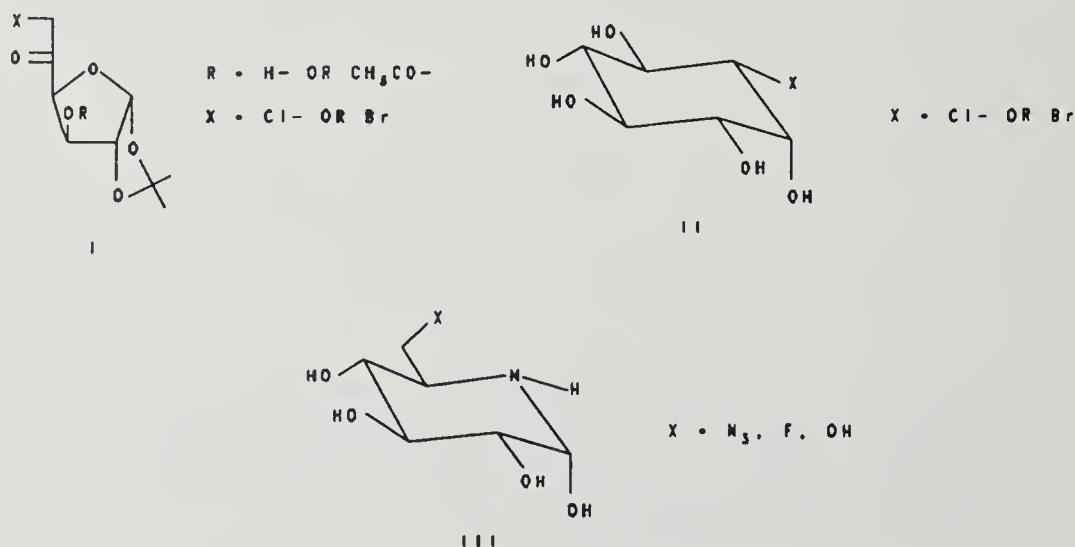
INFLUENCE OF BORON ON POLYCARBOSILANE SYNTHESIS. Xinjian Xie, Adriane Ludwick and Taleb Ibrahim, Chemistry Department, Materials Research Laboratory, Tuskegee University, Tuskegee, AL 36088

The conversion from polydimethylsilane to polycarbosilane was established by Yajima and his coworkers in 1975. Boron was used as a catalyst to improve this conversion for commercial production. In order to determine the effect of boron on the conversion mechanism, it is necessary to establish an effective method to get samples which belong to different reaction times, and to analyze these samples quantitatively. High reaction temperature under an inert atmosphere and poor product solubility make this determination difficult. In the Materials Laboratory of Tuskegee University, a special reaction unit has been used for the conversion reaction. The samples can be taken from the system continually during the reaction. The sample analysis includes solubility, NMR spectra for Si-H, Si-CH₂, and Si-CH₃ bonds, UV for Si-Si bonds, GPC for molecular weight, and IR for Si-H, Si-CH₂, and Si-CH₃ bonds. The mineral oil (Nujol) mull technique was used for quantitative IR analysis of solid samples. The reproducibility of this approach was established. The influence of boron in this conversion will be determined by analysis of the results. The conversion mechanism will be established. (Supported by ONR/URI, Contract No. N00014-91-J-4035.)

Abstracts

SYNTHESIS OF PROTECTED 6-DEOXY-6-HALEGENO-5-KETO-D-GLUCOSE DERIVATIVES AS INTERMEDIATES IN THE PREPARATION OF CHIRAL CYCLITOLS. David W. Morton and Donald E. Kiely, Dept. of Chemistry, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

Compounds of type (I) are used as intermediates in the preparation of natural products such as cyclitols (II) and nojirimycin (III) derivatives. Two general routes to the title compounds will be discussed.



ACCURATE NMR PARAMETERS IN MONOSUBSTITUTED BENZENES. Marietta Domensino and Charles L. Watkins, Department of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294-1240.

Recently, we became interested in obtaining accurate ¹H and ¹³C NMR chemical shifts and ¹H-¹H coupling constants for aromatic compounds. Examination of current NMR textbooks revealed that the ¹H NMR data that were referenced were obtained at 60 MHz about twenty-five years ago. Thus, we initially checked the reliability of the reported data for thirteen monosubstituted benzenes by obtaining the ¹H NMR spectra at 300 MHz. Then, using quantum mechanical simulation and iteration techniques, accurate ¹H NMR chemical shifts and coupling constants were obtained. These data are compared with literature values. Similarly, ¹³C NMR chemical shifts for the monosubstituted benzenes were measured and are compared with reported literature values. Finally, techniques for correlation of ¹H and ¹³C NMR chemical shifts and rapid spectral assignment will be discussed. Examples for 1-D ¹³C spectral editing (APT, Attached Proton Test), ¹³C-{¹H} single frequency decoupling, and 2-D ¹³C-¹H Heteronuclear Correlation will be presented.

Abstracts

N-BENZOYLAMINOPHENYLSULFONYLAMINO ACIDS: MULTISITE-DIRECTED ALDOSE REDUCTASE INHIBITORS. R. Alan Davis¹, Charles A. Mayfield², Mike McManus², and Jack DeRuiter¹, ¹ Division of Medicinal Chemistry, Department of Pharmacal Sciences, School of Pharmacy, Auburn University, AL 36849, ²Departments of Oncology and Biophysics, University Hospitals, University of Alabama at Birmingham, Birmingham, AL 35294

To date, of the aldose reductase inhibitors (ARIs) studied in our laboratory, the 4-{N-[(benzoylamino)phenyl]sulfonyl}amino acids are among the most potent members. As a function of the amino acid substitution (glycine, N-phenylglycine, R- and S- α -phenylglycine, and N-methylglycine), relative structure-inhibition relationships (SIRs) with aldose reductase (ALR2) were derived. From consideration of these SIR trends, in conjunction with the multiple-inhibition and competition analyses, it was apparent that these compounds had an unique mechanism of inhibition. Such novel binding resulted from interaction of the aroyl and amino acid moieties at their respective substrate and inhibitor sites within the ALR2 domain. However, this mutual two-site interaction did not account for the inhibitory differences observed within a regiosomeric series. For example, in the benzoylaminophenylsulfonylglycine (BAPSG) family, the relative IC₅₀ values increased from 0.41 μ M (4-BAPSG), to 7.0 μ M (3-BAPSG), to, finally, 70 μ M (2-BAPSG) as the benzoylamino fragment was moved around the phenylsulfonylglycine. Thus, it remained to be determined if the cooperative binding was maintained in the 2- and 3-regiosomers. As a result of these questions, other regiosomeric compounds were synthesized and kinetically analyzed. Using the same amino acid substitutions of the 4-regiosomeric series, the 2- and 3-regiosomeric counterparts were analyzed with respect to their relative SIRs. Other compounds, where the substrate (aroyl) moiety was varied (phenacetyl, cinnamoyl, benzyl, acetyl), were also considered. From these results, the 3- and 4-regiosomers inhibited ALR2 with similar mechanism of inhibition with slight deviation exhibited by the 2-regiosomers.

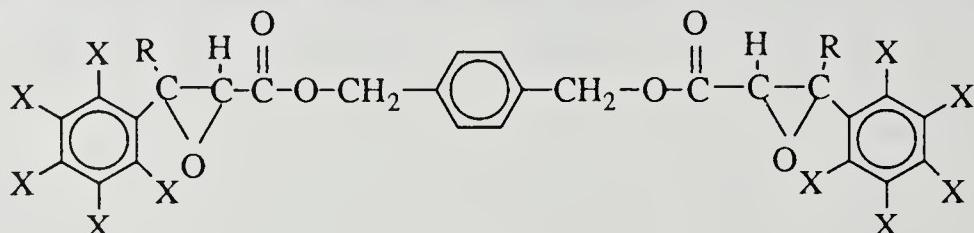
PHENYL-CONTAINING POLYCARBOSILANES: SYNTHESIS AND CHARACTERIZATION. Kegin Ma, Adriane G. Ludwick and Taleb H. Ibrahim, Chemistry Department, Materials Research Laboratory, Tuskegee University, Tuskegee, AL 36088.

Phenyl-containing polycarbosilanes, useful as precursors for ceramic materials, were synthesized using polysilastrene and polyborodiphenylsiloxane. Reaction times were varied for the synthesis of the phenyl-containing polycarbosilanes. The solubility of the resulting polycarbosilanes in various organic solvents ranged from 10 percent to 96 percent. Molecular weights and polydispersities were measured. "Polycarbosilanisity", a measure of the extent of conversion of polysilane to polycarbosilane, was calculated from ¹H NMR spectra to be approximately 50 percent for all soluble portions. The phenyl-containing polycarbosilanes will be used as precursors for novel phenyl/titanium-containing polycarbosilanes, also to be used as preceramic polymers. (Supported by ONR/URI, Contract No. N00014-91-J-4035.)

Abstracts

SYNTHESIS AND CHARACTERIZATION OF A NEW FLUORINE-CONTAINING EPOXY RESIN. Jianxin Ren and Adriane G. Ludwick, Chemistry Department, Tuskegee University, Tuskegee, AL 36088.

The objective of this study is to synthesize and characterize a new epoxy resin containing the ester functional group and fluorine atoms (1a). It is rationalized that the



ester group will improve compatibility of the fluorine epoxy with common amine curing agents. In comparison with a nonfluorine-containing epoxy resin (1b), the fluorine-containing resin should be more water resistant. Both 1a and 1b are designed so that control of the glass transition temperature can be achieved. This should increase the versatility of the use of the system. The nonfluoroepoxy has been synthesized by a Darzen's condensation reaction. Several reaction conditions were examined. The purification was attempted by column chromatography. The product was characterized by IR, ¹H-NMR, and ¹³C-NMR. The fluoroepoxy synthesis is underway.

STRUCTURE-INHIBITION STUDIES WITH ALDOSE REDUCTASE INHIBITORS DERIVED FROM FUNGI. Jack DeRuiter and R. Alan Davis, Department of Pharmacal Sciences, School of Pharmacy, Auburn University, AL 36849. John M. Jacyno and Horace G. Cutler, Richard B. Russell Center, USDA, ARS, P.O. Box 5677, Athens, GA 30613.

The fungal metabolites citrinin (4,6-dihydro-8-hydroxy-3,4,5-trimethyl-6-oxo-3H-2-benzopyran-7-carboxylic acid) and DHMI (3,4-dihydro-6-methoxy-3,7-dimethyl-1H-2-benzopyran-8-ol), as well as certain synthetic derivatives have been tested for their ability to inhibit aldose reductase isolated from rat lens. Citrinin and its reduced analogue, dihydrocitrinin, were found to have significant inhibitory activity ($IC_{50} = 10 \mu\text{M}$), whereas the other analogues including DHMI, methyl-DHMI and the N-methyl carbamate of DHMI were 3-10 times less inhibitory. While citrinin possesses a reactive quinone methide moiety and thus may be capable of alkylating of the enzyme, no irreversible inhibit of aldose reductase was observed in enzyme kinetic studies. Spectroscopic (NMR) studies revealed that citrinin exists predominantly in the form of its hemi-acetal in aqueous media, suggesting that the lack of reactivity results from the rapid hydration of citrinin under enzyme assay conditions.

Abstracts

SYNTHESIS AND CHARACTERIZATION OF THERMALLY STABLE POLYMERS.

Rahul D. Patil, James Jackson, and Himansu M. Gajiwala, Dept. of Chemistry, Tuskegee University, Tuskegee, AL 36088.

In this project an attempt is being made to synthesize new polyimides having good thermal stability and better processability, using heterocyclic diamine -- acridine yellow and different dianhydrides. Due to the poor reactivity of the diamine, two step polyimide synthesis at low temperature was unsuccessful. Polymerization reactions were therefore carried out at elevated temperatures in different polar aprotic solvents. Dimethyl formamide, Dimethyl sulfoxide and N-methyl-2-pyrrolidinone (NMP) were used as solvents for polymerization. NMP yielded the product with 100% imidization. Reaction conditions were optimized in terms of percentage solids, reaction time, temperature and molecular weight. The reactivity of acridine yellow was theoretically estimated using HYPERCHEM. The resulting new heterocyclic polyimides have high thermal stability. Besides good thermal stability, these polyimides are expected to have better processability and insulating properties due to the presence of bulky methyl groups.

ENZYME AMPLIFICATION-THE GLUCOSE OXIDASE/GLUCOSE DEHYDROGENASE CYCLE AND POSSIBLE APPLICATIONS. Moore U. Asouzu, Shawn Mansfield, Kimberlyn Ballard, Rachael Leopold, and Teresa Sims, Troy State University, Troy, AL 36082.

In enzyme amplification, a substrate is passed through a cyclic pathway many times with the aid of two or more enzymes and coenzyme. At the end of these cycles, the product accumulated or reagent consumed is measured and related indirectly to the concentration of the substrate in the cycle. Because product accumulation or reagent consumption in such a cycle is usually more than stoichiometric, the measured signal is much higher than usual, and this phenomenon is the basis for enzyme amplification. We will present the glucose oxidase/glucose dehydrogenase amplification cycle, and propose how this system may be beneficial as a detection scheme in solid-phase immunoassays.

Abstracts

THEORETICAL STUDIES ON THE REARRANGEMENT OF PHENYLCARBENE. Tracy P. Hamilton, Department of Chemistry, University of Alabama at Birmingham, AL 35294.

One of the models proposed for the observed reactivity of phenylcarbene (I) is one in which a ground state triplet is in thermal equilibrium with a slightly higher energy singlet. However, even the energy gap between the singlet and triplet states is not known for certain. Semiempirical calculations give values for the singlet-triplet difference that range from 2.2 to 19.2 kcal/mol. First principles methods have been used with fairly good basis sets to obtain 15.6, 9.9 and 7.9 kcal/mol for the singlet-triplet energy splitting for Hartree-Fock, CI and Davidson corrected CI, respectively. The errors in the answers given by these methods can be estimated from using them on methylene, which has an accurately known singlet-triplet energy gap. Some possible intermediates and transition states in the rearrangement of singlet and triplet phenylcarbene will also be examined. Among the interesting structures proposed are a bicycloheptatriene, cycloheptatrienylidene, and cycloheptatetraene.

IMMOBILIZATION OF CHOLINE OXIDASE AND ACETYLCHOLINESTERASE ON GLYCERYL-COATED CPG AND ITS APPLICATION TO HPLC SEPARATION OF ACETYLCHOLINE AND CHOLINE. Shawn Mansfield and Moore U. Asouzu, Troy State University, Troy, AL 36082.

The assessment of acetylcholine and choline profiles of tissue samples is very useful in the study of neural activities and disorders. HPLC coupled with post-column enzymatic conversion with acetylcholinesterase and choline oxidase, and amperometric detection of hydrogen peroxide on Pt electrode continues to be the only method used to determine these neurochemicals in a real sample. Acetylcholine and choline are neither chromogenic nor electroactive. We will present the results of HPLC quantitation of these neurochemicals based on amperometric oxygen electrode along with the advantages and the disadvantages of this system.

Abstracts

Microscale Determination of Molar Mass By Mixed Melting Points.
Dawn Kirkland, Sandra Padgett, Joseph Stewart, Maurice Ware,
Massimo D. Bezoari, Division of Natural Science and Math,
Livingston University, Livingston, AL 35470

The molar masses of compounds can be determined by making mixtures of known composition with a "solvent" compound having a high cryoscopic constant. The difference in melting points between the pure "solvent" compound and the mixture is obtained using capillary melting point tubes and milligram quantities of mixtures. The molar mass of the "solute" compound is calculated after the molality of the "solution" is deduced. The method works surprisingly well with common experimental errors of less than 5%. A greater degree of error is observed if the solids have not been mixed well. The method has advantages over the usual larger scale methods in that: a) smaller quantities of materials are required; b) less waste is generated; and c) students learn the technique of taking accurate melting points.

REDUCTION OF QUINONE AT AN ENZYME-MODIFIED GLASSY CARBON ELECTRODE AS A POSSIBLE ROUTE TO ENZYME AMPLIFICATION. Moore U. Asouzu,
Shawn Mansfield, and Kimberlyn Ballard, Troy State University,
Troy, AL 36082.

In enzyme amplification, a substrate is passed through a cyclic pathway many times with the aid of two or more enzymes and coenzyme. At the end of these cycles, the product accumulated or reagent consumed is measured and related indirectly to the concentration of the substrate in the cycle. The requirement that a coenzyme be present is expensive in many instances, and may even lead to reduced amplification through enzyme inhibition. We have immobilized horseradish peroxidase on a Jaffamine-modified glassy carbon electrode. By reducing the quinone product formed when catechol is used as substrate for the enzyme at this electrode, we are able to achieve amplification without the use of a coenzyme. We will present the immobilization method along with the results obtained to date. We will propose further how this system may be beneficial as a detection scheme in solid-phase immunoassays.

Abstracts

GEOLOGY

ENVIRONMENTAL AND ENGINEERING GEOLOGY OF CARBONATE ROCKS IN MADISON COUNTY, ALABAMA. Paul H. Moser and Karen F. Rheams, Geological Survey of Alabama, 420 Hackberry Lane, Tuscaloosa, AL 35486

Madison County is underlain predominantly by carbonates of Mississippian age at the lower elevations, and by sandstone, shale and coal of Pennsylvanian age at the higher elevations. The cavernous nature of the carbonate rocks over approximately 90 percent of the county is, in many cases, directly or indirectly responsible for a variety of environmental and engineering problems. More than 300 caves in Madison County have been located on topographic maps and mapped by tape, compass and inclinometer. These interconnecting openings are often large in the subsurface and may allow the rapid movement of the ground water generally in a southerly direction toward the Tennessee River. These interconnecting solution features of varying sizes furnish the conduit system through which pollutants may be carried over long distances in the subsurface. Caves and widespread subsurface solution openings provide some potentially damaging structural and engineering dilemmas. Specialized subsurface foundation treatments have been designed to accommodate these anomalous conditions. Sinkholes in Madison County appear to be prevalent but not abundant in number. The majority of these sinkholes appear to be formed by a mechanical erosion of the regolith overlying a conduit system in the underlying carbonates through which silt-laden drainage is carried downward and out of the area. These sinkholes, in some cases, provide direct access of contaminants and contaminated water to the ground-water system.

TRACER-DYE TECHNIQUES AND GROUND-WATER FLOW IN CARBONATE ROCKS, MADISON COUNTY, ALABAMA. Karen F. Rheams and Paul H. Moser, Geological Survey of Alabama, 420 Hackberry Lane, Tuscaloosa, Alabama 35486.

In conjunction with a study of the endangered Alabama cave shrimp (*Palaemonias alabamae*), tracer-dye investigations have been conducted to determine general and specific ground-water flows and to delineate subsurface basins and potential recharge areas of significant caves and springs in west-central and southeast Madison County, Alabama. Two artificial types of tracers, Blankophor BBH (an optical brightener) and Fluorescein CI Acid Yellow 73 (a fluorescent green dye) have been utilized in the study area. The tracers are recovered with detectors (colloquially known as "bugs") from possible points of intersection with the groundwater flow, such as springs, cave stream resurgences, and surface streams. Tracer-dye investigations in any given area have been hampered by a lack of suitable injection points. Although the study area is in a karstic terrain, many sinkholes are either closed or are only open to the ground-water system during limited periods of heavy precipitation. Tracer-dye tests are not entirely conclusive. Positive test results demonstrate a hydrologic connection between the input point and recovery point, but negative results are not proof of an absence of hydrologic connection. Non-uniform tracer-dye test results within the area of study are due to a number of factors, such as dilution, multi-level conduit versus diffuse subsurface flow regimes, sampling frequency, and animal and human vandalism. Much has been learned over the past 3 years concerning ground-water flow patterns in selected areas of Madison County, but much has yet to be perfected about dye-tracing techniques in this carbonate terrain.

Abstracts

AN IMPROVED CARBONATE POROSITY CLASSIFICATION. David C. Kopaska-Merkel, Geological Survey of Alabama, PO Box O, Tuscaloosa AL 35486-9780.

The genetic carbonate-porosity classification of Choquette and Pray has proven to be flexible and is widely used. Three modifications to this classification increase its usefulness. First, modifiers indicating the nature of the precursor particles are added to moldic and intraparticle pores. (Choquette and Pray suggested this informally in the appendix to their paper.) The second modification concerns partial molds, or secondary intraparticle pores, which are considered separately from molds because (1) they have differing spatial distributions, (2) different kinds of particles follow different diagenetic pathways; e.g., in some reservoir rocks, ooids become molds, whereas co-occurring pellets are transformed into ellipsoidal "sacks" of secondary intraparticle pores, and (3) molds and secondary intraparticle pores differ systematically and significantly in their petrophysical characteristics. Secondary intraparticle pores are small clusters of small pores, surrounded by pore systems that may be finer or coarser, whereas molds are individual large pores surrounded by finer pore systems. Secondary intraparticle pores are divided into **cement-reduced moldic pores** (recognized by Choquette and Pray), **microvuggy secondary intraparticle porosity**, formed by the partial dissolution of particles, and **intercrystalline secondary intraparticle pores**, commonly formed by the partial dolomitization and subsequent partial dissolution of a particle. These three fabrics are commonly restricted to the interiors of particles, and do not transgress particle boundaries. The U.S. Department of Energy partially supported this research.

AN OVERVIEW OF MINERAL PRODUCTION IN ALABAMA. Lewis S. Dean, Geological Survey of Alabama, 420 Hackberry Ln., Tuscaloosa, AL 35486.

Utilization of current and historical nonfuel mineral production data is an important factor in assessing the economic and technical development of the state's mineral industries. Mineral production data provide insight to exploration effort and reserve identification by the mineral industry and consumption, trade, and conservation practice. The earliest commercial operation (mineral production unrecorded) was in 1780 for clay used in making brick and tile at Mobile. Other early commercial production occurred in 1809 in Washington Co. for salt, 1818 in Franklin Co. for iron ore, 1827 in Tuscaloosa Co. for sandstone (building stone), 1831 in Chilton Co. for gold, 1838 in Talladega Co. for marble, and 1840 for lime and limestone. State mineral production was first recorded in 1840 for clay (brick and earthenware), stone (limestone and marble), iron, and gold. For the period 1880-1992 mineral production has been lead by limestone and dolomite (801.7 million short tons (mst)) [and associated manufacture of lime], sand and gravel (438.9 mst), iron ore [1880-1975] (374.5 million long tons), clay (104.8 mst), marble (29.1 mst), bauxite (6.6 mst), and sandstone (4.7 mst). Intermittent production for graphite took place in 1910-29 (50.8 million pounds (m pds)) and 1942-53 (30 m pds); for talc in 1955-76 (130,000 short tons); for flake mica in 1968-80 (1.6 mst); for gold in 1831-1949 (49,495 troy oz.); and minor production of barite, cassiterite, chert, phosphate, pyrite, sheet mica, talc, tantalite, and stone (building stone, granite, and quartzite). For the period 1970-92 production has been lead by limestone and dolomite (532.2 mst) in Shelby Co. (30%) and Jefferson Co. (19%) from the Cambrian Conasauga Formation-Ketona Dolomite and Ordovician Newala Limestone; Madison Co. (8%), Colbert Co. (7%), and Morgan Co. (7%) from the Mississippian Bangor and Tuscmibia Limestones; and Marengo Co. (4%) from the Cretaceous Demopolis Chalk. Sand and gravel production of 261.8 mst has been principally from Montgomery Co. (17%), Elmore Co. (8%), Macon Co. (7%), Tuscaloosa Co. (4%), and Russell Co. (4%) from Quaternary alluvium and terrace deposits, and Mobile Co. (8%) from the Citronelle Formation. Clay production of 60.5 mst from 1970-92 consists of common clay (45%), shale (29%), fuller's earth (14%), bentonite (6%), fireclay (4%), and kaolin (2%). Currently other significant production consists of bauxite, dolomitic marble (Chewacla Marble), marble (Sylacauga Marble Group), salt, stone (building stone and granite), and recovered sulphur.

Abstracts

GEOTECHNICAL ASPECTS OF LANDSLIDE CHARACTERIZATION IN HUNTSVILLE, ALABAMA. S.J. Vitton, Dept. of Civil Engineering, The University of Alabama, Tuscaloosa, AL 35487-0205.

Due to accelerated growth in and around the metropolitan area of Huntsville, Alabama, development pressures are being exerted on the slopes of Monte Sano, Green, and Huntsville Mountain Ridges. These ridges, which are remnants of the once more extensive Cumberland Plateau, are formed from a cap rock of Pottsville Sandstone of Pennsylvanian age underlain by a sequence of Mississippian aged limestones, shales and sandstones, most notable the Pennington and Bangor Formations. Through weathering and mass wasting, both residual and colluvial soils exist on the slope with some of the colluvium reaching depths in excess of 20 m. While normal slope processes are apparent, such as erosional movement of the soil and toppling failures of the Pottsville Sandstone, both ancient and recent landslides can also be observed in the colluvium. The colluvium, while variable in nature, is generally composed of sandy clays along with considerable sandstone fragments from the overlying Pottsville Formation. Due to the potential for earth movement in the form of debris flows and larger scaled landslides, the City of Huntsville has adopted a Mountainside Development Zoning District Ordinance, which requires that a geotechnical investigation be performed on the slope stability of the proposed development. To aid in the implementation of this ordinance, an investigation is currently being conducted to assess the characteristic of the earth movement in an attempt to develop landslide potential maps for the Huntsville area. While numerous complex factors are involved in the mass movement of soil, some of the more important factors being considered in this investigation are (1) the strength of the colluvium, which has been found to be highly overconsolidated, (2) the dilatational effects of the sandstone fragments in the colluvium, (3) changes in soil mineralogy with weathering, (4) saturation by infiltration of surface water as well as migration of ground water, and (5) the cause and effect relationship of sinkhole development on slope stability.

SCANNING ELECTRON MICROSCOPE STUDY OF MICROFOSSILS FROM THE TALLADEGA SLATE BELT, ALABAMA. Denny N. Bearce, Dept. of Geology, University of Alabama at Birmingham, Birmingham, AL 35294. Mark C. Koopman, Dept. of Materials Engineering, University of Alabama at Birmingham, Birmingham, AL 35294.

The Talladega slate belt is the westernmost belt of the southern Appalachian Piedmont metamorphic province in Alabama and Georgia. It contains lower greenschist facies metasedimentary and metavolcanic rocks ranging in age from latest Precambrian or Early Cambrian to Devonian. These rocks have been thrust-faulted onto Paleozoic sedimentary rocks of the Appalachian Valley and Ridge province. Stratigraphic relationships have been established between the Talladega slate belt and the Valley and Ridge province through the rare occurrence of fossils in a few of the Talladega slate belt formations. These fossils have also constrained structural models of the Talladega slate belt. Many stratigraphic intervals of the Talladega slate belt remain of uncertain age. However, SEM study of one such interval has revealed the presence of microfossils ranging in size from two to twenty microns. These microfossils have not been identified, but some are of the size and shape of spores. Most of the forms have been pyritized, but some are carbonaceous. The microfossils occur in black, carbonaceous, phyllitic metashale. No comparable forms have been found as yet in rocks of known age. These microfossils are relatively abundant, and current study is directed toward establishing their biologic affinity, age range, and usefulness in correlation.

Abstracts

IMAGING OF LOW-INTENSITY CATHODOLUMINESCENCE IN AUTHIGENIC QUARTZ, NORPHLET SANDSTONE, OFFSHORE ALABAMA. Ralph L. Kugler, Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486 and Kitty L. Milliken, Department of Geological Sciences, University of Texas at Austin, Austin, TX 78712

Cathodoluminescence (CL) of authigenic quartz cannot be detected by cold-cathode luminescence devices attached to optical microscopes routinely used in studies of carbonate cements. However, recently available CL detectors on scanning electron microscopes, utilizing photomultiplier technology similar to that used in optical telescopes by astronomers, can characterize previously unrecognized, low-intensity CL in quartz cement. In offshore Alabama, quartz cement in Norphlet sandstone has two occurrences; (1) pervasive, pore-occluding quartz cement in the "tight zone" at the top of the unit and (2) millimeter-scale, quartz-cemented nodules in porous sandstone lower in the unit that contain inclusions of earlier anhydrite cement. These two occurrences of authigenic quartz have distinct CL characteristics. Combined CL and backscattered-electron imaging of samples from the "tight zone" revealed complex zonation and assemblages of crystals that were unexpected in quartz overgrowths that appear optically continuous with polarized-light microscopy. The multitude of crystals in individual intergranular spaces may reflect nucleation sites at breaks in chlorite grain coats or nucleation on detrital quartz grains out of the plane of observation. Although causes of CL in quartz are poorly understood, CL zonation in most crystals apparently reflects normal growth banding. However, some crystals appear to be sector zoned. Detrital grains and cement are locally fractured, with authigenic quartz filling fractures. Quartz-cemented nodules display the most complicated CL patterns. Generally, luminescence is duller and zonation is indistinct. The most surprising result was the high degree of compaction in the nodules. Rounded luminescent patches within quartz-cemented nodules appear to be detrital fragments that were not visible with other forms of microscopy. Some detrital grains contain complex embayments, unrelated to pressure solution. Imaging of low-intensity CL promises to be a significant tool in deciphering the evolution of quartz cement in hydrocarbon reservoir sandstone, as well as in evaluation of compaction and brittle deformation. Additionally, knowledge of CL zonation in authigenic quartz can guide and constrain collection and interpretation of fluid inclusion and stable isotope data.

Abstracts

FORESTRY, GEOGRAPHY, CONSERVATION, AND PLANNING

SIGNS, THEIR PURPOSE, TYPE, AND USE. Wilbur B. De Vall, Proxy Services, Ltd, Auburn, Alabama 36830-2505.

Signs are efficient means of direct, mass communication which are available to everyone. They may provide directions, announce events, promote a product, convey a message, or just provide information. Signs may convey an image of you or your business, telling others who you are, what service or product you are offering, and how to contact you. When one cannot talk with people, signs do the communicating such as "WET PAINT", "BEWARE OF THE DOG", and similar messages. The word SIGN has other meanings. A sign may point out a location of a particular business by use of a symbol - three balls for a Pawn Shop. A gesture or motion is a sign such as "sign of the cross". The word may be an indication of a situation - "no sign of life". In astronomy, the 12 signs of the Zodiac have specific meanings. When a check is written, a person 'signs' it. A coach may 'sign' a new player. In business, a sign is some form of board, plate, or space used to advertise, guide, or inform. The final objective of signs is to create an image. A good sign which creates a good image, will help others remember the business, its name, product, or service. Its value pays off when people return to the business as repeat purchasers. The cost of a sign depends on its size, material used in construction, and embellishments such as reflective paint or artificial lighting. Each should be considered a business expense, designed to increase income, create the proper image for the product or service, and be kept in first-class condition by frequent maintenance. A poorly designed sign, of inadequate size, in a poor location, and improperly maintained will be a liability to any business whether large or small.

THE RENEwed POPULARITY OF DOWNTOWNS. Jason Claxton, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

The characteristics that made the downtown a focus of economic and social life include its location at crossroads of a regional transportation network, its diversity of land uses, and its concentration of activity in a compact area. After World War II, the decline of the downtown affected housing, retailing, and industries. This decline can be traced to the invention of electric streetcars and the automobile. Today, the downtown has turned towards a pedestrian-oriented environment. This paper will explain the influence that the downtown had on a community's economic and social life. These influences include the decline of the downtown market places, pedestrian and transit systems, and technological and social forces.

Abstracts

GIS AND REMOTE SENSING ANALYSIS OF WETLANDS IN HUNTSVILLE, ALABAMA. Benjamin A. Ferrill, Planning Department, City of Huntsville, 308 Fountain Circle, Huntsville, AL 35804.

The purpose of this study is to develop a GIS and remote sensing approach to wetland identification and delineation and to verify the results by ground-based studies. Digital data sets (including U.S. Fish and Wildlife Service National Wetland Inventory (NWI), Soil Conservation Service hydric soils (1958), topography and drainage, current land use, color infrared (CIR) photography, a January, 1990 Landsat Thematic Mapper (TM) image, and other data sets) are being compared to establish the spatial associations that constrain the most accurate delineation and classification of wetlands. Preliminary results from comparisons of hydric soils, NWI, and TM analysis from three quadrangles indicate less than 50% agreement between data set pairs. Comparison of these data with current land use, CIR photography, topography and drainage and field-based studies help to define types of disagreement. For example, the NWI maps erroneously identified several bottomland hardwood forests as wetlands, whereas, they commonly failed to show farmed or cleared wetlands. The TM analysis missed many small wetlands because of the 30m pixel resolution and misidentified others, particularly marginal wetlands and wetlands with mixed cover types. Changes in land use including ditching to drain wetlands, slope paving for flood control, and filling of wetlands for commercial/residential development have altered soil hydrology in several areas. The highest agreement between respective data sets is in large wetlands that are permanently or seasonally flooded.

THE LOCATION AND ANALYSIS OF CHERT PITS TO DETERMINE PALEOSTREAM CHANNELS. Debbie Harrison and Deborah Wilson, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

According to 1968 geologic maps of Northwest Alabama, the Upper Cretaceous Gordo Formation, part of the undifferentiated Tuscaloosa Group, is a blanket deposit on the east side of the Mississippi Embayment. A hypothesis has been proposed that asks: Could the Gordo Formation have been deposited by paleostreams that emptied into the Mississippi Embayment rather than a marginal marine deposit? To test the hypothesis, our research included: a review of the literature on the Gordo and Coker Formations of the Tuscaloosa Group; studying geologic maps of Colbert and Franklin counties in Northwest Alabama; and, field work to investigate, map, and analyze Gordo exposures in the study area. At each locality the thickness and elevations of the Gordo were determined. Preliminary results are inconclusive, and it is hoped that further field work will produce a definitive answer to the hypothesis.

Abstracts

THE GEOGRAPHY OF THE 1992 PRESIDENTIAL DEBATES. Cynthia L. Sutherland, Department of Geography, University of Alabama, Tuscaloosa, AL 35486. Gerald R. Webster, Department of Geography, University of Alabama, Tuscaloosa, AL 35486.

Due to our reliance on the electoral college, U.S. presidential elections are intrinsically geographic events. In their campaigns successful candidates must address issues pertinent to varying geographic places and scales. For example, in the 1992 presidential election popular wisdom has held that Bill Clinton's success was partially due to his attention on domestic issues, most notably the economy. In contrast, many perceived George Bush's campaign as neglecting the domestic economy and emphasizing his record in international affairs. Due to their attention to geographically defined issues and places the three 1992 presidential debates provide an opportunity to consider these common assertions. This paper uses a content analysis of place names mentioned by each of the three presidential candidates during each debate. Place names are then classified by geographical setting including a U.S. vs. foreign dichotomy. These geographical setting classifications are then used to determine the spatial emphasis of places by each of the three candidates. This paper finds that all three candidates stressed domestic locations more than foreign locations, but this domestic emphasis was indeed slightly greater in Bill Clinton's responses during the three debates.

ECONOMIC AND ENVIRONMENTAL IMPLICATIONS OF AN IMPROVED ETHANOL PRODUCTION TECHNOLOGY. Eric N. Rahimian, Dept. of Economics and Finance, Alabama A&M University, Huntsville, AL 35762.

Several studies exist about the feasibility of an economically viable ethanol production from corn and sugar cane. Ethanol production from corn stalks, corn cobs, sawdust, grass clippings, old newspapers, the sludge generated from the paper mills, municipal solid waste (MSW) has recently gained a technological momentum. The improved technology utilizes genetic engineering to produce a more productive bacteria (superbug) which has the ability to produce ethanol from almost any kind of plant material. The cost of ethanol production may go down to 45 to 50 cents per gallon which makes it a good rival to gasoline. The byproducts of the new technology are said to be useful in other productive processes. This paper reviews the recent improvement in the ethanol production technology and its economic and environmental implications. Although a detailed cost-benefit analysis of full-scale implementation of the new technology is not yet available, there seems to be enough evidence to support further allocation of funds and attention to the potentials of the new technology. The implementation of the new technology is expected to improve the quality of our environment and to reduce our dependence on foreign sources of energy.

Abstracts

THE LOSS OF WETLANDS IN THE URBANIZED AREA OF MADISON COUNTY, (ALABAMA) BETWEEN 1979 AND 1989. Claudette P. Hall, Dept. of Community Planning and Urban Studies, Alabama A&M University, Normal, AL 35762.

The purpose of this research was to determine wetland losses in the Urbanized Area of Madison County, Alabama from 1979 to 1989. The specific objectives were: to determine the amount and rate of wetland loss, identify the factors contributing to wetland loss, and identify those factors threatening wetlands in the study area during the period under investigation. Wetland losses were determined by converting map and photographic data to digital format, then measuring and recording wetland acreages. Aerial photographic interpretation and field investigation determined wetland losses between 1979 and 1989, revealed factors threatening wetlands and identified new land uses that have replaced wetlands over the study period. Within the eleven year study period, approximately 5 percent of the study area's wetlands have been destroyed. Residential and commercial developments are the major contributing factors. Wetlands continue to be threatened by various activities. These findings formed the basis for documenting the past, present and future status of wetlands in the Urbanized Area of Madison County.

KEY WORDS: Wetlands, Urbanized Area of Madison County.

USING SATELLITE IMAGERY TO DETECT PINE BEETLES IN BANKHEAD.
Roger Taylor, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

The University of North Alabama's Geographic Research Center is currently researching the possibility of early detection of pine beetles in Bankhead National Forest through the use of multispectral satellite images. Trees killed by pine beetles are not only an eye sore, but are also a threat to the timber industry and the economy of Alabama. This project uses anniversary date imagery to determine if stress, exhibited by the damaged trees, is detectable in the satellite imagery. The stressed spectral response will indicate one of two things: The tree has either been infested by pine beetles or the tree is exhibiting stress and is a good candidate for a pine beetle attack. This project seeks to answer two questions: "Can the satellite imagery be used to detect trees under stress, thereby predicting where the pine beetles will move next?" and "Can the satellite imagery be used to detect current locations of pine beetles in order to save the Alabama Forestry Commission time and money in searching for the locations?" This project is funded by the Alabama Forestry Commission.

Abstracts

THE EDUCATIONAL REQUIREMENTS OF THE GIS INDUSTRY: WHAT UNIVERSITIES SHOULD PROVIDE TO UNDERGRADUATE GEOGRAPHY MAJORS. Lisa Keys-Mathews, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

The Geographic Information Systems (GIS) market has grown steadily over the past several years and this growth is predicted to continue. Given this growth, many employment opportunities are available for college graduates with an interest in this technology. Undergraduate institutions that provide a curriculum to support the GIS industry must prepare students for these positions. There are four sectors of the GIS employment market which include software development, sales and marketing, user applications, and support functions (including education, hardware, and software support). Needless to say, a student's talents and interests will determine in which of these sectors they will work. What the educational system must provide, however, is direction to the students in these areas. This paper serves to provide suggestions relative to classes, work experience, and projects in each of the four sectors based on practical hiring experience and interviews with professionals in the field.

THE EFFECTS OF CLEARCUTTING ON THE ECOSYSTEMS OF THE BANKHEAD NATIONAL FOREST. Sherry L. Bishop, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

The present practice of clearcutting in the Bankhead National Forest of Alabama is a highly destructive method of timber harvesting. The researcher will present evidence to show how this practice adversely affects the Earth's biosphere, geosphere, atmosphere, and hydrosphere. Overwhelming evidence indicates that clearcutting causes a loss of biodiversity through habitat destruction. Current research of forest ecosystems have proven that reduced diversity limits a forest's ability to deal with stress. The spatial distribution patterns of a replanted forest can affect the health of that forest by reducing its ability to cope with natural calamities. This paper supports the thesis that present practices and attitudes must change if forest ecosystems are to survive. Suggestions are offered on the changes and modifications required.

LIVING IN THE RAINFOREST: IF WE LIVE WITH IT, CAN THEY LIVE WITHOUT IT? Rhonda Grissom, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

The news media constantly publicizes the fact that the rainforests of the world are being devastated. What is often not discussed is the fact that the citizens of these countries are conducting the deforestation to survive. The deforestation occurs for short-term economic benefits, but in the process the environment is being destroyed. How can this process be slowed to an acceptable rate of recovery? This paper will examine the effects of deforestation on cultures, the environment, and the future of medicine. In addition, it will offer alternatives to deforestation, among them ecotourism, selling of plants with medicinal value, change of landownership distribution, and the developmental research of plants.

Abstracts

HIGH TECHNOLOGY COMPLEXES AS PORTRAYED IN MAGAZINE ADVERTISEMENTS, 1955-1990. Roberta Haven Webster, Department of History, Political Science and Geography, Samford University, Birmingham, AL 35229.

The United States is in the midst of social, economic and political transformation that is fundamentally altering the nature of spatial relationships. The purpose of this paper is to investigate the changing role of place and location in this transformation with special emphasis on the locational impact of high technology activities. The data set for this study was generated from a content analysis of more than 500 magazine advertisements from Business Week and Time between 1955 and 1990. Nearly one hundred variables were initially identified as potentially significant to this transformation process, and the frequency of their occurrence in each advertisement was recorded. Twenty-three variables were selected for further study and entered into a principal components analysis in an effort to identify major socio-spatial dimensions within the data. The principal components analysis resulted in the identification of six dimensions, including a "new manufacturing/high technology" dimension. A closer examination of this dimension showed that it was dominated by ads from the latter portion of the study period, specifically post-1975, and that these same ads portray not only corporate movements to locations outside the traditional manufacturing belt but also increasing placelessness.

THE INFLUENCE OF THE TENNESSEE RIVER ON SETTLEMENT PATTERNS IN NORTH-WEST ALABAMA. Deborah Wilson and Angelia Mance, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

The Tennessee River has exerted a profound influence on the settlement of Northwest Alabama. A plentiful source of good water, fertile lands, and transportation routes were primary reasons for settlement in the vicinity of the river. The Tennessee River has been important to the economic development of Northwest Alabama. For example, the presence of shallow water necessitated the establishment of a break-in-bulk point to allow the trans-shipment of goods from the river to land transport. The establishment of port facilities contributed to further growth and economic development of the area. Sequential occupants of these locations ranged from the Prehistoric Indians to the cotton planters of the Antebellum period to the current inhabitants of the valley.

THE USEFULNESS OF SIMCITY IN A PLANNING CLASS: A STUDENT PERSPECTIVE. Jeffrey S. Henderson, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

Zoning is one tool used by city planners; SimCity, a computer "game" that simulates the development and growth of a city, is a teaching tool that can allow future planners the opportunity to sharpen their use of this tool. The user is both a city planner and a mayor. The objective of the "game" is to develop a healthy city on a given landscape that is well designed and properly budgeted. This paper describes from a student perspective the benefit of using SimCity in a classroom situation. The paper also addresses the practical planning concepts that SimCity demonstrates compared to the theoretical concepts taught in class.

Abstracts

USING CENSUS DATA TO SUPPORT UNIVERSITY NEEDS IN STATISTICAL MAPPING.
Amy Aldridge, Dept. of Geography, Univ. of North Ala., Florence, AL
35632.

In the Geographic Research Center at the University of North Alabama, large numbers of maps are produced for various grants and contracts as well as to support University marketing and recruiting. In the past, these maps were generated using *Atlas*Graphics/Atlas*Draw*, a basic computer mapping tool. The data was normally collected and input manually into the system. This project integrates the Census Bureau's STF-1A Population and Housing data available on CD-ROM with ESRI's ArcUSA 1:2 million data. The resulting database will allow the faculty to present a graphical representation of the university community yesterday, today, and tomorrow. This database will also serve as an excellent tool for strategic and long-range planning for the University. This paper explains the database design and development as well as the applications.

IMAGERY: A POTENTIAL POSSIBILITY. Priscilla Holland, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

The National Aeronautics and Space Administration (NASA) has promoted the use of its satellite imagery from the time of its first collection in 1974. The community of users in the United States has increased from a small cadre of pioneers to a field practiced by thousands. The arena of research in the use of satellite imagery as a teaching tool within the secondary schools has been limited because of the cost of the hardware and software required to manipulate these data. During the eighties, as the price decreased, universities and colleges were able to afford systems for teaching and training tools. In the past year such systems have become even more affordable and, in the opinion of this researcher, the field has reached a point where the incorporation of this technology into the curriculum at the secondary level is crucial. Not only does satellite imagery bring new resources to education, but research shows that it interests and motivates students to learn.

AN INNOVATIVE METHOD FOR DEVELOPING A GROUND RECEIVING STATION FOR NOAA AND GOES SATELLITES. Darryl Shelton, Dept. of Geography, Univ. of North Ala., Florence, AL 35632.

NOAA and GOES satellites are constantly sending remotely sensed data of the earth to receiving stations around the globe. This data is free to all that have the basic hardware and software. With a minimum of expense and effort, a geography or earth science department at a university or secondary school can assemble a satellite downlink receiving station. The data downlinked from these satellites, along with their associated orbital tracking, can be used in the classroom, or as student projects. Data can be used to instruct students in meteorology, earth science, geography, and physics. This paper describes how to construct and set up the basic components of a NOAA and GOES satellite ground receiving station.

Abstracts

PHYSICS AND MATHEMATICS

STATISTICAL ANALYSIS OF ION DEPLETION IN A SPACECRAFT WAKE.
Richard H. Comfort, Center for Space Plasma and Aeronomics Research and Physics
Dept., Univ. of Ala. in Huntsville, Huntsville, AL 35899. Uri Samir, Dept. of
Geophysics and Planetary Sciences, Tel-Aviv University, Tel-Aviv, Israel.

Observations made by the Retarding Ion Mass Spectrometer (RIMS) on the Dynamics Explorer 1 spacecraft provide data for this study of plasma wakes. Because the spin-plane of the spacecraft lies in the orbital plane, the RIMS detector can view in both the direct forward (ram) and direct backward (wake) directions as the spinning spacecraft moves through the ambient plasma. Approximately 5000 one-minute averages of the wake-to-ram countrate ratios for both H⁺ and He⁺ form the database for this study. We examine the variation of these ratios with ion Mach number, normalized spacecraft potential, and normalized body size. Results from this study confirm earlier results based on a much smaller data set that the wake-to-ram ratio varies most sensitively with the ion Mach number. With this larger data base, however, we are also able to identify systematic variations of this ratio with the normalized potential, which were not apparent in the previous study. We also attempt to separate the physical influences of the normalized body size from those of the normalized potential, both of which appear to affect the wake-to-ram ratio comparably. From these results we can gain insight into the differences between these plasma wakes and similar wakes in neutral gases.

GYROGRAPHICS: VISUALIZING SOLIDS IN CALCULUS. Judy E. Massey,
Division of Natural Sciences and Mathematics, Livingston University,
Livingston, AL 35470.

Students have difficulty visualizing solid figures. The student's first introduction to graphing these figures is generally in Calculus II, when the student is introduced to solids of revolution. Gyro-Graphics is a marvelous tool for graphing these and other three-dimensional solids. The student can input various functions and revolve them about any horizontal or vertical axis of revolution. In addition, a student can graph a plane curve and actually manipulate the axes to find the shape of the inverse relation. The inverse trigonometric functions are especially nice to visualize with GyroGraphics. Spherical and cylindrical coordinates can also be used to graph solids of various types. Parametric space curves are always interesting to work with mathematically, but difficult to visualize. These are easy to graph with GyroGraphics and students can better understand the concepts from calculus when they are reinforced by visual input. This software can also be used in upper level senior seminar courses, multivariable calculus or linear algebra. Dr. Jerry Johnson has contributed some of the examples which will be demonstrated in the talk. (Dr. Johnson is a faculty member at the University of Oklahoma in Stillwater, OK).

Abstracts

SYNTHESIS AND CHARACTERIZATION OF SCHIFF'S BASES FOR NONLINEAR OPTICS* K.Bhat, M.D. Aggarwal, W.S. Wang, Department of Physics and K.J. Chang, Department of Chemistry, Alabama A&M University, Normal, Al 35762.

Organic materials with nonlocalized π electron systems are very attractive for nonlinear optics. Schiff's bases are an important class of materials which are getting increasing attention for nonlinear optical applications. In the present paper, N-Salicylidene aniline and various substituted aniline derivatives have been synthesized in an effort to explore new nonlinear optical materials. These compounds are synthesized by condensation of an aldehyde with an appropriate amine in a monohydric solvent. It is aimed to study the effect of various substituents and positions of these substituents on the second harmonic generation of the synthesized compounds. In all cases meta position and chloro substituted derivatives seem to show better SHG results.

* Work supported under NASA grant NAG8-125 and NSF Project RII-8802971

COMPUTER-BASED INTERACTIVE DEMONSTRATIONS IN PHYSICS.* Antonino Carnevali and Anthony Blose, Dept. of Physics & Earth Science, University of North Alabama, Florence, AL 35632.

Recent research in physics education conducted at various universities across the nation has shown that classroom lectures are ineffective vehicles for teaching basic concepts in kinematics and dynamics. At the University of North Alabama, we are exploring the potential of computer-based interactive classroom demonstrations as a more effective way to promote understanding. A motion detector and force probe are interfaced to a computer; real-time graphs of the actual motion of a cart are produced and projected onto a screen. An interactive protocol is used to foster students' understanding. Standardized pre-tests and post-tests were administered to monitor students' progress and evaluate the effectiveness of the method. The configuration, the demonstrations, and the protocol will be described, and the first results of our study will be presented.

* This work was partially funded by an NSF grant (administered by Dickinson College, Carlisle, PA) and a UNA research grant.

A GEOMETRIC SERIES DEVELOPMENT OF ERROR BOUNDS FOR POWER SERIES.
Larry Parks, Mobile College, Mobile, AL 36663-0220.

This paper discusses the use of Geometric Series in determining the error bounds for both Taylors and McLaurin series. The technique has the advantage of providing rather simple error bound calculations while at the same time requiring only the fundamentals of Geometric Series. The technique, perhaps, would be an excellent introduction to the summation of infinite series for students of technology, requiring a minimum of mathematical acumen.

Abstracts

ANOMALOUS PLASMA HEATING IN THE EARTH'S IONOSPHERE.

Trevor W. Garner, R. Hugh Comfort, and Phil G. Richards Center for Space Plasma and Aeronomics Research, Univ. of Ala. in Huntsville, 301 Sparkman Dr., Huntsville, AL 35899

The Earth's ionosphere is a region of the upper atmosphere composed of plasmas created by the interaction of solar radiation and neutral gases. The density and temperature of the electrons in this complicated region are two of the most important features of the ionosphere. Any further investigation of the ionosphere must begin with a full understanding the structure of the density and temperature. In general, ionospheric electron temperatures rise sharply at sunset, decay slowly through the day, and fall rapidly at sunrise. Using data taken by the incoherent scatter radar facility at Millstone Hill, Massachusetts, we have occasionally observed anomalously high electron temperatures during the night, comparable to the noontime temperatures. In this study, we statistically analyze eight years of data taken by the Millstone Hill radar and present the results.

POISSON'S EQUATION VIA SPREADSHEET. David R. Crotty, Dept. of Physics and Earth Science, Univ. of North Ala., Florence, AL 35632

The two dimensional Poisson equation may be solved using a spreadsheet. This method provides a pedagogic advantage of being visual and it emphasizes a localized algorithm for solving either the Poisson, or the simpler Laplace, equation. The spreadsheet uses the fact that the Laplacian solution at a point is the average of the solutions at neighboring points. Boundary conditions and source densities are entered into spreadsheet cells, and successive iterations (recalculations) of the spreadsheet cause the cells to approach the solution of the potential.

ANGULAR MOMENTUM IN N DIMENSIONS. William J. Boardman, Div. of Science and Mathematics, Birmingham-Southern College, Birmingham, AL 35254.

The description of angular momentum as a vector quantity is possible only if one refers to instantaneous values, because of the non-vector nature of finite rotations. In a space of four or more dimensions, a vector description becomes inadequate, and it is necessary to recognize angular momentum for what it is: an anti-symmetric second rank tensor. This paper describes the commutation relations the angular momentum operators in N dimensional space must satisfy, and the ultraspherical harmonics that form the angular part of the wave function of a particle in an ultraspherically symmetric potential.

Abstracts

MORPHOLOGY OF BENZIL CRYSTALS GROWN BY THE CZOCHRALSKI TECHNIQUE. A. Conner, A. Tan and W. S. Wang, Dept. of Physics, Alabama A&M Univ., Normal, AL 35762.*

Good quality single crystals of Benzil ($C_6H_5-CO-CO-C_6H_5$) have been successfully grown by a modified Czochralski technique. Flat interfaces and consequent defect-free crystals were obtained at the optimum rotation speeds of 10 rpm. Higher rotation speeds produced concave interfaces with frequent entrapment of air bubbles. The outline of the Benzil crystals exhibited a competition between the trigonal and hexagonal forms in which principal faces changed into sub-faces and vice-versa. The probable cause of this reversal is being investigated. Since the rotation speed and the pulling rate were held constant throughout the growth process, minor fluctuations in temperature may play a possible role in this reversal.

*This study was supported by NSF Grant MRCE-8802971.

Abstracts

INDUSTRY AND ECONOMICS

SEXUAL JOKES IN THE WORKPLACE: HUMOR OR HARASSMENT?
Sylvanus S. Ogburia; Mark Andreoni and Jackie Warren.
School of Business, Alabama A&M University, Normal, AL

Sexual harassment has become a topic that has gained national attention since the Clarence Thomas and Anita Hill episode. It is now important more than ever before to identify all facets of sexual harassment and determine how people feel towards workplace jokes that may have some sexual overtones. The purpose of this research was to determine to what degree, if any, the exposure to sexual jokes in the workplace may be construed as sexual harassment. The result of the study shows that younger people (ages 20-29) viewed workplace jokes with sexual flavor as being more offensive than older employees. Those within (ages 40-49) were the least offended by jokes that have sexual components. Unlike the single people, the married employees thought that the jokes were extremely offensive. Among the various ethnic groups studied, the Blacks showed the highest level of dissatisfaction with jokes that were laden with sexual overtones. Overall, men were more offended than women.

One glaring but disturbing finding of the study was the compartmentalization of jokes. If jokes are from your circle of friends and social groups, they are laughed over, dismissed and no one gets offended. But if jokes are made by a "stranger", an outsider or a person you do not like, nerves are stirred up and emotion would rise. It would appear plausible that we should not evaluate "jokes" but rather we should evaluate the "source" of jokes.

PERCEPTIONS OF SEXUAL HARASSMENT IN THE SHOALS AREA. Rick A. Lester,
Sandra S. Carpenter, Department of Management, Marketing, and CIS, and
Lorraine Glasscock, Department of Accounting, University of North
Alabama, Florence, Alabama 35632.

The present study will measure aggregate as well as gender-based attitudes of respondents toward the issue of sexual harassment. There were 892 participants from Colbert and Lauderdale Counties in Northwest Alabama. Preliminary findings indicate that as a result of the Clarence Thomas confirmation hearing, respondents were made more aware and sensitive to the issue of sexual harassment in the workplace. However, a clear majority did not see the issue as a work environment problem. The most alarming finding was that almost three-fourths of the respondents agreed that working women must accept some level of sexual harassment on the job. Further, almost two-thirds of the participants stated that companies should not be responsible for training employees regarding the issue of sexual harassment and more than a majority felt that the government had no role in the legislation of sexual harassment policies.

Abstracts

WHAT BUSINESS WANTS COLLEGES TO TEACH IN BUSINESS SCHOOLS.
Clayton Kelly, Gerald Crawford, R. Keith Absher, and
William S. Stewart, School of Business, University of North
Alabama, Florence, AL 35632-0001.

The purpose of the research was to determine what qualities employers feel are most important when hiring new employees for clerical and managerial (or management training) positions. A population of employers to be personally interviewed was scientifically selected from four employer sectors: manufacturing, wholesale/retail trade, services, and government. These groups were stratified to match the proportions found in a nine county primary catchment area served by the University of North Alabama. Two hundred and fifty-three interviews were conducted by graduate students during the Fall semester of 1992. One question dealt with ranking the importance of 27 variables found in the literature concerning the preparation of college students for the workplace.

The ten most important qualities desired were rank ordered as follows: (1) Good work experience, (2) Trustworthy and honest, (3) Good, positive attitude, (4) Hard worker, does more than expected, (5) Good work habits, (6) Dependable, on time, (7) College graduate, (8) Understands specific college course material, (9) Gets along with others, diplomatic, and (10) Fast learner, smart. There are implications that more time and attention should be devoted in the classroom to helping develop desirable attitudes and work habits.

COMPARISON OF GENDER NEUTRAL ATTITUDES TOWARD WORKING WOMEN. Sandra S. Carpenter, Rick A. Lester, Department of Management, Marketing, and CIS, and Lorraine Glasscock, Department of Accounting, University of North Alabama, Florence, Alabama 35632.

Has the American business become gender neutral? In the past decade, statistics provided in scholarly works have shown that the actual number of women in the workforce, in general, and in management, in specific, has increased drastically. Clearly the law and thus citizens have been in support of such move since the mid-sixties. The present study is an attempt to determine first if the attitudes concerning women in the workforce have kept pace with the increases in employment figures; secondly, if some correlations can be made between sex and gender-based attitudes; and, thirdly, if there have been changes in the attitudes concerning women in the workplace since a 1987 use of this survey. The responses to the survey indicate that attitudes are clearly drawn by sex although they remain diverse. Although both studies showed a greater acceptance of women in the working environment, clear obstacles still surfaced. The results will be presented by looking at the four categories of questions dealt with in the present and past studies: (a) women are provided employment breaks; (b) the use of affirmative action; (c) where is the woman's place?; (d) women's duties.

Abstracts

TAX REFORM IN ALABAMA. Paulette Alexander, Department of Management and Marketing, University of North Alabama, Florence AL 35632. James G. Alexander, Department of Economics and Finance, Alabama A&M University, Normal AL 35762.

Tax reform and education reform have been the subject of numerous debates and proposals associated with the Alabama's legislative processes of the last several years. Yet Alabama still ranks at or near the bottom in virtually every ranking evaluating education systems in the nation. Alabama was the only state in the nation to register a decline during the eighties in the percent of its citizens who are college graduates. Projections show that two-thirds of all jobs created in the nineties and beyond will require some post-secondary education. A recent survey found that major companies locate elsewhere because of Alabama's lack of quality education and lack of skilled workforce. Seventy-five percent of the state budget is devoted to education. Further education spending and education problems impact other essential services. For example, high school dropouts account for 90% of the prison population. Both the level and the structure of taxation in Alabama must be overhauled. Our present tax structure fails in all the standard measures of tax systems: it is regressive, complicated, expensive to administer, subject to downward fluctuations in the economy and limited in the amounts of revenue that can be generated. Alabama's tax structure is detailed in the Constitution, making changes expensive, time-consuming and unlikely. Further the predictability of tax collections is hampered by numerous legal challenges currently on the docket of the state court systems. Education is the cornerstone on which our economic destiny is based. And tax structure and level changes are the only method for achieving real education reform in Alabama.

CLASSIFICATION OF SHOP SCHEDULING IN A FLEXIBLE MANUFACTURING SHOP. Hossein Jamshidi, Dept. of Business Administration, Alabama A&M University, Normal, AL 35762.

Shop scheduling can be classified as flow (closed) shop or job (open) shop. The proposed study investigates the conditions in which one approach would be preferable to another in terms of optimizing a performance criterion such as the total cost. The variables or factors used in this study are:

- Frequency of job arrivals in the work center
- Number of different jobs arriving at the work center
- The ratio of setup cost to holding cost

The proposed study will help managers choose an appropriate approach to overcome the scheduling and planning problem and, as a result, improves overall shop performance and reduces costs.

Abstracts

CONDUCTING AN IMAGE STUDY OF A REGIONAL UNIVERSITY. Gerald Crawford, R. Keith Absher, and William S. Stewart, Professors, School of Business, University of North Alabama, Florence, AL 35632.

The purpose of the research was to determine how 18 various groups or "relevant publics" perceived their exchange relationships with the University. It was important to know what each group liked and disliked about the school and to determine specifically what the University could do to better serve the needs of each group within the context of its mission and its available resources. Some of these groups were: current undergraduate students, current graduate students, faculty, staff, administration, alumni, the local community, parents, prospective employers, prospective students, high school counselors, and media representatives.

Following the identification of "relevant publics", it was then necessary to design a research plan for each group. Various research techniques were used to systematically gather data within established confidence and precision guidelines. Some of the methods used to gather data were: personal interviews, mail questionnaires, focus group interviews, and simple observation. The data was subsequently reviewed for accuracy before being entered into computerized databases and statistically analyzed. The results were compiled for each group and are being used by the administration, faculty, and staff to make positive changes at the University.

Computerized accounting information systems use among Shoals area manufacturers. T. Morris Jones, Sarah Brown, and Richard A. Hudiburg, University of North Alabama, Florence, AL.

Falling prices of computer hardware and software have made it more attractive for businesses, even very small one-owner businesses, to use accounting software. Prior research, however, reveals that no accounting software package is dominant and a package that is selected is rated high in one or more of the following factors: quality of documentation, telephone support, software cost and ease of use. A random sample of 120 companies was drawn from a list entitled Shoals Area Manufacturers. The majority of the companies (58%) did not use a computerized accounting package. Of the 50 companies (42%) that did use a computerized accounting package: (1) the average number of employees using the accounting package was 4.4, (2) only 16% allowed access to a modem at home, (3) 42% had no provision for hardware backup, (4) all had provision for software backup and 56% of these did a daily backup. There was no dominant software package used by these 50 companies. Peachtree, RealWorld and Great Plains accounting software were each used by three companies.

Abstracts

CORPORATE PERCEPTIONS OF THE AMERICANS WITH DISABILITIES ACT (ADA) OF 1990. Sylvanus S. Ogburia; Brian Wood; Jean Dow and Mary Epps. School of Business, Alabama A&M University, Normal, AL 35762.

The American with Disabilities Act was signed into law on July 26, 1990. The Act was patterned after section 504 of the Rehabilitation Act of 1973. The purpose of this study was to measure the initial corporate perception to ADA.

An attempt was made to determine what the respondents understood by the term, "reasonable accommodation" as defined in ADA. The understandings were very broad. To some, a "reasonable accommodation" is any accommodation that does not place undue burden or hardship on the company. To others, it is "anything that gives the disabled the same accessibility as anyone else". Still to others, it is any changes in the workplace made to accommodate disabled employees so long as it did not cause a financial hardship.

The study also tried to establish if ADA has forced companies to make some structural modifications in order to comply with ADA. Large percentage of the manufacturing companies affirmed that some degree of structural modifications were required. Structural modifications cited were redesigning bathrooms, construction of handicapped ramps and parking spaces, and redesigning some assemble line jobs.

RETAIL PRICING POLICIES: A COMPARISON OF THEORY AND PRACTICE. Donna Yancey and Keith Absher, Dept. of Marketing and Management, Univ. of North Alabama, Florence, AL 35632-0001.

A questionnaire was developed from the "Mason, Mayer and Ezell, Pricing Check-list for Retailers". This questionnaire was pre-tested and administered to a group of retail store managers. A total of 234 usable questionnaires were returned. Of the 234 responses, 37 (15.8%) were classified as convenience stores, 63 (26.9%) were classified as shopping stores and 134 (57.3%) were classified as specialty stores. The researchers found that these classifications of stores were more similar in their pricing policies than expected. Shopping stores did exhibit a tendency to follow more aggressive pricing policies than did convenience stores or specialty stores. All three types of retail stores were very aware of competitors prices and had some type of device to monitor competitors prices. Price competition was an overriding factor in the setting of the original price for all types of stores.

Abstracts

PROSPECTS FOR A CHALLENGER LEARNING CENTER: DEVELOPING A HIGH-TECH CORRIDOR IN ALABAMA. Paulette Alexander, Department of Management and Marketing, University of North Alabama, Florence AL 35632-0001.

The University of North Alabama (UNA) was approved as a Challenger Learning Center site in January 1992, by Challenger Center for Space Science Education. UNA is situated approximately halfway between Huntsville, Alabama and Iuka, Mississippi. Residents of the area surrounding UNA comprise a substantial portion of the workforce for the many and varied high technology space- and defense-related companies and agencies in the Huntsville area and for the Advanced Solid Rocket Motor plant near Iuka. The University is an integral part of the educational system for the region, with a wide variety of degree programs. UNA strives to support K-12 education in the region through many of its projects and programs. Challenger Center for Space Science Education is a non-profit education organization, created by the families of the shuttle flight 51-L crew. Space exploration is utilized as the unifying and tantalizing theme throughout the programs of Challenger Center. Communication, problem solving and teamwork are key elements of the programs, creating positive experiences that raise students' expectations of success, foster a long-term interest in science, math and technology, and motivate students to pursue studies in these areas. The Challenger Learning Center combines computer technology and space exploration scenarios to create missions in simulated space station and mission control environments. A Challenger Learning Center will be a critical element in economic development for the region, as additional employers locate in the region and require technically skilled and highly motivated workers.

VOLUNTEER MANAGEMENT: A LOOK AT THE FACTORS TO CONSIDER WHEN MANAGING VOLUNTEERS. Jo Carwile, School of Business, University of North Alabama, Florence, AL 35632-0001.

This paper explores issues relevant to the management of volunteers in nonprofit organizations. The issues examined included the volunteers' motivations for volunteering, the benefits and costs to organizations by using volunteers, and the attitudes of organizational employees toward volunteers.

Exploratory research was also conducted to gather primary data concerning the motivations behind the choice of college students to volunteer. A questionnaire was used to collect information from a convenience sample of 55 business students from the University of North Alabama. The questionnaire asked the students to rank different motivational factors. The factors included obtaining insight and guidance for their career, building their resume, making friends or social contacts, wanting to do something useful, because someone asked them, it was an activity sponsored by their employer or school, they felt a sense of obligation, they would enjoy the work, because of religious concerns or social reasons, and because their family or friends would benefit.

Abstracts

QUALITIES DESIRED IN EMPLOYEES OF SMALL BUSINESSES IN NORTH ALABAMA. Margie S. Crocker, Gerald Crawford, and Jo Carwile, School of Business, University of North Alabama, Florence, AL 35632-0001.

The purpose of this study was to determine qualities small businesses sought when hiring personnel and to compare those qualities to those considered important by the University of North Alabama Business Faculty. It was felt that information obtained would be useful to faculty as they plan for instruction and to students as they prepare for the job market. A questionnaire was used to gather information from 40 University of North Alabama School of Business faculty and 197 small business people from the University's service area. Replies to the questionnaire revealed unanimous agreement between the faculty and small business people on the first two qualities, both considering a good positive attitude number one and honesty and trustworthiness number two. Getting along with others was rated third by business people and fourth by the faculty. Being a hard worker was rated fourth by small business people and third by the faculty. There was additional agreement in ranking five through ten with dependability, good communication skills and high standards being included by both groups. There was some disagreement in rankings five through ten. The faculty included writing skills, resourcefulness and college graduation. Business ranked good work habits, learning quickly and good team player. These rankings were mutually exclusive.

NORTH AMERICAN FREE TRADE AGREEMENT. Robert Trimm, Dept. of Economics and Finance, Univ. of N. Alabama, Florence, AL 35630. Veronica A. Free, Dept. of Economics and Finance, Univ. of N. Alabama, Florence, AL 35630.

The North American Free Trade Agreement has the potential to encompass Canada, the United States, and Mexico, representing a \$6 trillion economy embracing about 360 million people. Currently, Canada is the largest trading partner of the U.S., with Japan being second. The third most important trading partner is Mexico. The trading block of this hemisphere could represent a formidable power against southeastern Asia and European trading entities. Gains from trade or the profit motive is the essential factor in stimulating the discovery of new methods of production. By reducing tariffs and giving equal access to a larger potential market, producers are able to extend this possible market and lower costs because of economies of scale. There are an estimated 20,000 different tariffs for U.S. goods exported to Mexico. The average Mexican tariff is 11 percent. Under the North American Free Trade Agreement, these tariffs will be reduced to zero over the next 15 years. The purpose of this paper is to study the disruptions that will occur in the U.S. production markets, especially in regard to labor. Some industries will be more adversely affected in the U.S. than others. However, it is anticipated that the economies of growth in Mexico will further increase the demand for U.S. products, thus limiting adverse factors in the long run.

Abstracts

CHARACTERISTICS OF ORGANIZATIONS WITH FORMAL SEXUAL HARASSMENT POLICIES AND PROCEDURES. Sylvanus S. Ogburia; James Broomfield; Sue Shelton and Betty Cardon. School of Business, Alabama A&M University, Normal, AL 35762

Headlines announcing penalties levied against individuals and organizations have become commonplace to most of us that we pay little attention. This study was done to determine the degree to which organizations in the North Alabama area have written sexual harassment policies.

The study revealed a high correlation between number of years in operation with formal sexual harassment policy. The longer the organization has been in operation the more likely the organization shall have formalized its sexual harassment policies. The size of the organization was also found to be highly significant. The large organizations tended to have formal sexual harassment policies. It was also found that organizations which were predominately women and also with large proportion of female executives had relatively no sexual harassment policies in place. This may mean that female executives handle sexual harassments quite differently than their male counterparts. It could also mean that since males know that they are in minority, the tendency to harass women may not be there. Also, organizations that were predominately white-collar employees were more likely to have formal sexual harassment policies than organizations with predominately blue-collar employees.

The Collaboration Process of Linking Education and Economic Development (LEED): A Prototype for the Appalachian Regional Commission and the State of Alabama. Ann S. James and Brinda Lisano, Economic Development Institute, Auburn University, Alabama, 36849-5252

The existing curriculum in many of Alabama's secondary and postsecondary schools may be inadequate to provide the education and training needed by students in order to meet the needs of the technological manufacturing industry. Education must be restructured if students are to be prepared to compete in an international job market. Auburn University Economic Development Institute, the State of Alabama, and the Appalachian Regional Commission, are using *Project LEED* (Linking Education and Economic Development) to create a collaborative linkage resulting in positive change within the education community. A Technology Preparation Team (TPT) designed strategies for working successfully with the community, for identifying the needs of high-technology manufacturing industries, and incorporating those knowledge, skills, and abilities into the course work of students at the secondary and post-secondary level. The delivery of the restructured curriculum to teachers through relevant and effective teacher training is a key element of the *Project LEED* prototype design. The improved skills of secondary and two-year college students in the area of computation, analytical ability, decision making, and communications skills will provide an improved quality of life for participating students, increased human resources, and a stronger economic base within Alabama.

Abstracts

NATIONAL DEBT: HAVE WE SQUANDERED OUR FUTURE ALREADY? Tom Mathew, Ph.D., Division of Business, Troy State University in Montgomery, Montgomery, AL 36195.

Some of the economic problems faced by the United States today are high levels of unemployment, the deterioration of the standards of education, the high rates of violent crimes, the unacceptable levels of foreign trade deficit and perhaps the most important of all, the ever increasing national debt. This paper addresses the issues of the national debt. At the end of 1979, the outstanding federal debt was \$852 billion (35.3% of GNP). At the end of 1991, the debt was \$3,820 billion (67.3% of GDP). One group of economists believes that the national debt is not a serious problem while a second group believes that it has become a very serious problem and should be dealt with without any further delay. The author presents statistical data to prove the seriousness of the problem including data on interest in absolute dollar amounts, as a percentage of the GDP, and as a percentage of the federal government outlays. The author emphasizes the effect of the size of the national debt and the interest payments (in spite of the current low interest rates) on the use of the fiscal policy as a tool in adjustments in business cycles. Various solutions are proposed by the author. Some of these are: increase in the marginal tax bracket, reduction in entitlements, increase in taxes in gasoline, tobacco and alcohol, elimination of certain subsidies to farmers, and reduction in defense related spending. In addition, elimination of wastes in the legislative and administrative branches of the government is strongly advocated.

AN ASSESSMENT OF THE CONTINUING EDUCATION NEEDS OF MINORITY- AND FEMALE-OWNED SMALL BUSINESSES IN HUNTSVILLE, ALABAMA. Marsha D. Griffin, Department of Marketing, and James G. Alexander, Department of Economics and Finance, Alabama A&M University, Normal, AL 35762.

During the Fall of 1992, 44 percent of the entries in the Northeast Alabama Directory of Minority and Woman Owned Small Businesses were interviewed to determine their perceptions of need for training in selected areas and their feelings about the benefits of various services that could be offered by an economic development organization. Most of the sample had been in business between 5 and 10 years, employed 5 or fewer persons, classified themselves as "technical," were owned by white women, and had annual sales between \$100,000 and \$499,999. Respondents felt the greatest need for assistance in getting government contracts and marketing. They were least concerned about technical advice and assistance in loan packaging. The respondents thought business development meetings, referrals of new business, workshops/seminars, and a monthly publication would be most beneficial. They were least excited about courtesy discounts from fellow members of a development association and a minority/woman-owned business exposition. Of the 46% which belonged to the Chamber of Commerce, 54% thought the services provided by the Chamber were justified by the cost; 34% thought their membership was either "very beneficial" or "pretty beneficial." Of the 22.6% which belonged to the Minority Suppliers Development Council, 48% thought the membership fee was offset by the benefits provided; 32.5% felt their membership was either "very beneficial" or "pretty beneficial." Regarding a membership fee for a new minority/female business development organization, most felt \$25 or less per employee was appropriate.

Abstracts

THE GENERATIONS--GAP OR GULF? James G. Alexander, Department of Economics and Finance, and Marsha D. Griffin, Department of Marketing, Alabama A&M University, Normal, AL 35762.

Each generation, almost congenitally, looks at its successor with eye askew--wondering why its children (and even younger siblings) differ from its own memory of childhood. This intergenerational dissonance reflects the combined effects of societal changes and flawed recollections. Technological and social dynamism as well as cataclysms such as wars and economic depressions exacerbate divergences of perspective and philosophy. Even intergenerational size differentials contribute. The Baby Boom generation, born in the early post-WW II period, has played a central role not only in defining the contours of social philosophy and debate for the past quarter century but also in a major socio-economic transformation favoring the old over the young. This large--and consequently powerful--generation which "gapped" from its elderly over civil rights, VietNam, and America's role in the world now finds itself faced with challenges from below. The coming-of-age of the Baby Boom generation has coincided with a historic shift, making the young materially disadvantaged to the elderly. This shift, and its attendant down-graded expectations, is part and parcel of the transforming composition, though not aggregate level, of demographic dependency. Today's middle-agers find themselves caught not in historically increasing overall dependency, but rather in a powerful trend toward aged rather than youthful dependency. (It should be noted, however, that very recent data suggest that this trend, too, is less firm than generally thought.) Instead of instigators of intergenerational conflict, Baby Boomers now find themselves in a position to play defense. The change of circumstances is perhaps best explained by the title of a recent Newsweek article: "First, Kill All the Boomers." Boomers must respond if the present gulf is to be reduced to the normal gap.

DOGMATISM AND FIEDLER: AN EXPLORATORY INVESTIGATION.

Kerry P. Gatlin and Charles Barrett, Department of Management and Marketing, University of North Alabama, Florence, AL 35631

A sample of one hundred sixteen management students completed questionnaires measuring their leadership style and the personality trait dogmatism. The leadership style survey identified transformational leadership and transactional leadership characteristics. The exploratory study's purpose was to determine if highly dogmatic students display leadership characteristics that differ from students with lower dogmatic personalities. The Chi Square test was used to test for significance. The study found that highly dogmatic students were significantly more likely to exhibit transactional leadership traits whereas students low in dogmatism were more likely to display transformational leadership characteristics. Given the rapidity of change in the business environment, the results suggest that further research into dogmatism might be useful in order to better prepare students for an environment requiring that they be more flexible and adaptive. For those subscribing to Fiedler's contention that it is better to place the manager in an environment consistent with his or her personality, high dogmatism students may need to be advised to seek careers in mature industries where change is less dramatic and stability is an asset rather than a liability.

Abstracts

U.S. AND U.K. MANAGEMENT STYLES: PERCEPTIONS OF BRITISH MANAGERS. Keith Absher, and Gerald Crawford, Dept. of Marketing and Management, Univ. of North Alabama, Florence, AL 35632-0001, and Glee Whitsett, Productivity Center, Univ. of Alabama, Tuscaloosa, AL 35486.

This study was largely exploratory in nature. In-depth interviews were used to collect information from top level British managers. All of the managers had traveled widely in the U.S.. The interviews were conducted over a period of three summers. The British managers were asked to give their perceptions of the differences between U.S. and U.K. management styles and business practices. British managers consistently said: (1) U.K. companies are risk averse while U.S. companies take more risks. (2) British businesses are much less consumer oriented than U.S. companies. (3) U.K. companies do not lay off employees, they employ or fire. (4) U.K. companies are more open about their problems. (5) The quality of service is not as important in the U.K. as it is in the U.S.. (6) U.K. companies make little or no provisions for the handicap. (7) British companies have the restrictions of two separate political institutions to comply with (EEC and British). (8) Security measures are much tighter in the U.K. because of the threat of bombings.

RUSSIAN FEDERATION: AN OVERVIEW OF THE MARKET ECONOMY. Veronica A. Free, Dept. of Economics and Finance, Univ. of N. Alabama, Florence, AL 35630. Maria Victoria Vitelli, Bradshaw H. S., Florence, AL 35630.

The former Soviet Union has always been a textbook example of an economy that depends on economic planning to make basic economic decisions of what to produce, how much and to whom the product is distributed. However, the Soviet economy failed to achieve satisfactory levels of growth and efficiency. This prompted officials to develop a number of reforms commonly referred to as "glasnost" (openness) and "perestroika" (restructuring). These reforms, begun in the late 1980's, marked the demise of central planning and the movement toward "market socialism". The change to a market economy has not been without great cost to the Soviet citizens. In fact, while Gorbachev has been hailed as a hero abroad, at home he has met with stubborn resistance. The purpose of this paper is to study the economic path of change in the former Soviet Union from a centrally planned economy to the new Russian Federation with greater reliance on the market economy.

Abstracts

RESEARCH TOOLS: SPSS CHAID--A NEW USE FOR AN OLD FRIEND.
Dennis W. Gibson Division of Business, Troy State
University in Montgomery, Montgomery, AL 36103-4419.

The contingency table is an array of counting numbers in matrix form. The matrix serves as a tool to facilitate an analysis of the relationship between two or more qualitative variables. Fledgling researchers are exposed to the Chi-Square test of independence and the Chi-Square Goodness of Fit Test early in their statistical methodology training. The training often then proceeds through a series of increasingly elaborate methods culminating with several exotic multivariate designs. The researcher is often left with the impression that good research is function of the elaborateness of the design. The Chi-Square technique is relatively easy for the consultant to explain and easily understood by the consumer. The new product by SPSS/PC+ entitled Chi-Square with Automatic Interaction Detection (CHAID) breathes new life into this statistical method and elevates understanding by consumers to a new level. The primary output of the CHAID algorithm resembles a decision tree. The nodes of the tree represent only the significant relationships specified by the researcher and detected in the analysis. It is no longer necessary to visually search through pages of tables looking for the significant relationships.

MANAGEMENT LISTENING SKILLS. Sandra K. Durham, Dept. of Office Systems Mgt., Alabama A&M Univ., Normal, AL 35762

Listening is a managerial tool that ties together the managerial functions of planning, organizing, leading, and controlling. It is an acquired skill that requires hearing plus discipline. It involves the development of a mind-set that shuts out internal and external barriers.

Research indicates that listening is the primary communication activity in terms of the time it consumes. Poor listening habits bring about costly consequences in business operations. Development of comprehension and retention skills assist managers in determining the value of messages.

Emphasis should be placed on categorizing listening skills into three types--concentrated, attentive, and casual--in order to improve the listening process.

ACTIVITY BASED COSTING: A REVOLUTION IN COST ACCOUNTING.
Jerry W. Ferry, Department of Accounting, University of North Alabama, Florence, AL 35632.

Activity Based Costing (ABC) is a new technique for allocating overhead costs to individual cost objectives. ABC uses new cost drivers, new cost behavior classifications, and cause and effect analysis to develop more accurate cost information for managerial decisions.

Abstracts

SCIENCE EDUCATION

EXPERIMENTS AND DEMONSTRATIONS TO INCREASE STUDENTS' UNDERSTANDING OF INTERACTIONS IN AQUATIC ENVIRONMENTS. Thomas E. Bilbo, Department of Biology, Mobile College, Mobile, AL 36663.

During January of this year, fifty-six students, who were enrolled in an Introduction to Biology course for non-majors, completed an aquatic biology questionnaire. The ten multiple choice questions included on the questionnaire were designed to ascertain the students' level of understanding of interactions in aquatic environments; the students' responses revealed a lack of understanding among a large number of the students. Since these students are future voters and leaders, their lack of understanding is disappointing. The students' poor performance on questions that involved an understanding of dissolved oxygen was particularly disturbing. If almost half of the students responding felt that aquatic organisms could split water molecules to get the oxygen they needed, then omitting this topic from introductory biology courses could have serious consequences. Inexpensive laboratory exercises and demonstrations designed to increase students' understanding of the following topics will be discussed: (1) the impact of biodegradable materials on dissolved oxygen levels, (2) the decrease in saturation concentration of dissolved oxygen with increases in temperature, (3) the increase in the use of dissolved oxygen by aquatic organisms as water temperature increases, and (4) the impact of high levels of phosphates and nitrates on aquatic environments.

THE CURRICULUM BURDEN: TEACHERS KEEP PUSHING THAT BOULDER. Mary W. Paramore, Dep't. of English, Enterprise High School, Enterprise, AL 36330.

Public school curriculum is increasingly burdensome due to the many rapidly-changing demands placed on it by a dysfunctional society. The traditional curriculum of science, math, social studies, language arts, and the fine arts was modified slightly in past decades as economic demands and social attitudes changed. Since the late 1980's a frantic public has relegated to the schools the social instruction previously provided by parents and the community, while concurrently demanding more academic and vocational instruction to enable graduates to compete in a global economy. Failure to fund these additions, along with vacillation about what curricular modifications are needed, has made the public schools' burden unmanageable.

Abstracts

ENVIRONMENTAL CHEMISTRY IN THE LABORATORY: PARAMETERS OF WATER QUALITY.
Mary Frances Dove, Division of Natural Sciences, Mobile College,
Mobile, AL 36613

Water quality is determined in the environment by the measurement of certain essential parameters: dissolved oxygen, biological oxygen demand, turbidity, pH, and the concentration of nitrate and phosphate. Many of these measurements can be made routinely in the field using commercial field kits and specific ion electrodes. However, the cost of field kits becomes expensive for a large class, and substitutes are desirable. Field kits are often based on standard procedures, such as the modified Winkler method for dissolved oxygen. These procedures are adaptable to the classroom laboratory. This presentation describes student activities in the Basic Environmental Technology laboratory at Mobile College, which uses both field and laboratory approaches for determining water quality.

SCIENCE OLYMPIAD IN ALABAMA. Steven D. Carey, Division of Natural Science, Mobile College, Mobile, AL 36663.

The Science Olympiad is an international nonprofit organization dedicated to improving science education, increasing student interest, competency, and literacy in science, and recognizing outstanding achievement in science education by students and teachers. These are accomplished through classroom activities, research, training workshops, and intramural, district, regional, state, and national Science Olympiad tournaments. The competitions are balanced between the disciplines of biology, earth science, chemistry, physics, computer science, and technology. Participants require a knowledge of science facts, concepts, processes, skills, and applications. Nationally, there are four Science Olympiad divisions: Division A1 (grades K-3); Division A2 (grades 3-6); Division B (grades 6-9); and Division C (grades 9-12). Currently, the Science Olympiad program in Alabama is organized into six Division C and three Division B regional olympiads and a state olympiad for both divisions. The Alabama Science Olympiad program is affiliated with the Alabama Academy of Science.

Abstracts

SOCIAL SCIENCES

THE PEACE BALLOT IN ENGLAND, 1935. Peter F. Barty, Dept. of History and Political Science, Univ. of North Alabama, Florence, AL 35632.

The British League of Nations Union organized the National Declaration on the League of Nations, or the Peace Ballot, in 1934 in an effort to force the British Government to follow a pro-League policy. While the Ballot was being administered and the votes tallied, public attention in Britain was focused on an abortive attempt by the League of Nations to deal with a major crisis in Abyssinia. Just as with today's crisis in the Balkans, the League seemed paralyzed and unable to act. 11,627,765 people cast ballots in this popular referendum. Proponents claimed that the results represented strong public support for League action, while opponents chose to read the results as indicating massive support for pacifism. The effects of the Ballot on British politics were largely intangible and difficult to determine. They did figure in the deliberations of the secret cabinet meeting held the day before Stanley Baldwin ditched his foreign secretary, Sir Samuel Hoare, for his role in formulating the Hoare-Laval Plan. Yet six months later Hoare was back in the cabinet, and in 1936 Baldwin was able to reject the Union's demands for oil sanctions against Italy with impunity. The Peace Ballot proved to be a financial disaster for the League of Nations Union. Conservatives in general resented the undertaking and many of them left the organization. Public attention was focused on the League in a moment of weakness. Disenchantment with the League was transferred to the Union, which thereafter lost whatever ability it may have had to influence the course of British politics.

OUR TROUBLED CHILDREN:ADRIFT IN A SEA OF DARKNESS. Mary W. Paramore, Dep't. of English, Enterprise High School, Enterprise, AL 36330.

Society's failure of its children has left teachers so ineffective that many who care deeply about their students are leaving the classroom. Our children's spirits are filled with the darkness of ignorance, loneliness, and fear. Their ignorance results from parents' failure to provide them with a foundation for learning in childhood. Their loneliness results from parents' physical and/or emotional abandonment of their children. Their fear results from increasing violence in their real world as well as their fantasy world. Such darkness of spirit leaves them incapable of learning in the classroom.

Abstracts

SALIVARY TESTOSTERONE IN CHILDREN WITH AND WITHOUT LEARNING DISABILITIES. S.W. Kirkpatrick, P.S. Campbell, R.E. Wharry, and S.L. Robinson, Depts. of Psychology, Biological Sciences, and Developmental Learning, The University of Alabama in Huntsville, AL 35899.

Although there is an hypothesis that abnormal levels of testosterone *in utero* may result in later learning disabilities, no data exist which are suggestive of such a linkage. However, it is known that the sex steroids exert organizational effects upon the development of the CNS, particularly in regard to reproductive behavior, and more recent findings suggest that higher brain functions also may be affected by steroid hormone secretion during critical periods in development. Consequently, we explored the possible relationship between testosterone secretion and learning disabilities by collecting saliva and measuring salivary testosterone levels in control and learning disabled children in an Alabama public school system. Learning disability was categorized according to criteria established in 1986 by the Alabama State Department of Education, and salivary testosterone was measured by a competitive displacement radioimmunoassay. The data sample included a total of 296 prepubescent children ranging from 6 to 13 years old with 32 of the subjects classified as learning disabled. The presence of learning disabilities was significantly associated with higher salivary testosterone. This was true for both entire sample and matched sample analyses in which control subjects were randomly selected to exactly match the age, race, and sex characteristics of the learning disabled group. The testosterone level for nearly 85% of children with learning disability ranked above the median testosterone value of non-learning disabled children. Mean testosterone level for children with learning disability was 17.1 pg/ml, while the mean value for control children was 10.8 pg/ml. The association between salivary testosterone levels and learning disabilities may be relevant to the possible etiology of this impairment in some individuals.

RECENT U.S. ARMED FORCES HUMANITARIAN MISSIONS. Col. Robert E. Pieroni, MC, USAR, Professor of Internal Medicine and Family Medicine, Dept. of Internal Medicine, Univ. of Ala., Tuscaloosa, AL 35487, and Chief of Professional Services, 75th Field Hospital, Tuscaloosa, AL 35401

In recent years, the U.S. military has become increasingly involved in peace-keeping missions as well as humanitarian relief operations. For example, after the liberation of Kuwait during the Persian Gulf War, U.S. forces engaged in Operation Provide Comfort in order to render emergency assistance to Kurds fleeing the Iraqi army. More recently, in Operation Restore Hope, thousands of U.S. troops are assisting the many Somalians threatened with starvation. Humanitarian efforts in Yugoslavia by U.S. military personnel are currently underway. In addition to these more publicized humanitarian efforts, U.S. forces continue to be engaged in scores of activities throughout the world which have tangibly benefited countless individuals and communities. As an example, Medical Readiness Training Exercise (MEDRETE) have greatly benefited numerous impoverished citizens, especially in Central and South America. We will discuss the mutually rewarding benefits accrued from our recent participation in such an exercise in an extremely poor, rural area of Argentina. Additionally, we will counter arguments proposed by some military commentators that humanitarian efforts could have tragic consequences on our forces' "fighting spirit," and that "peace-waging" should be left solely to non-military organizations.

Abstracts

SELF-DESCRIPTIVE CORRELATES OF AVOWED HAPPINESS. Charles E. Joubert, Department of Psychology, University of North Alabama, Florence, AL 35632.

Several situational and dispositional predictors of happiness have been previously reported by investigators. This research explored the relationship between self-definitional aspects of the self-concept and the subjective appraisal of happiness. The 216 subjects anonymously and voluntarily completed a questionnaire in which they rated themselves on 21 self-descriptors, including happiness, using six-point Likert scales. Also, each subject completed the Social Desirability Scale. The results indicated that happier men and women tended to report themselves as being more relaxed, aggressive, cooperative, trusting, conforming, and sociable; but less timid and introverted. Happier men but not happier women also described themselves as being more practical, religious, conventional, tolerant, and studious; but less self-centered and cynical. Happier women but not happier men also described themselves as being less lazy. These results suggest that happier people tend to describe themselves in positive terms; it is, however, premature to state confidently whether these happier people are that way because they have these traits in greater abundance, or simply because they have a more permissive and tolerant view of themselves. An overall implication of this research is that self-attributions do relate to happiness. Therefore, psychotherapies which encourage more favorable self-attributions should increase happiness in the recipient.

Gender differences in computer users' stress. Richard A. Hudiburg, Sara Brown, and T. Morris Jones, University of North Alabama, Florence, AL.

Measurement of computer users' stress was based on the Computer Hassles Scale. The Computer Hassles Scale was developed to measure stress (computer hassles) specific to human-computer interactions. Preliminary psychometric research, using a sample of college students enrolled in computer courses, with the Computer Hassles Scale showed it to be a moderately stable measure. The scale also showed initial convergent construct validity for measuring computer users' stress. The current study focuses on computer users' stress in a sample of subjects who work with accounting software. A questionnaire was mailed to 113 accountants for manufacturing companies in Northwest Alabama. Sixty five questionnaires were returned. The questionnaire contained the Computer Hassles Scale, the somatic complaint items from the Hopkins Symptoms Checklist, and requests for information about gender, age, education, and computer experiences.

The questionnaire was scored and Pearson product-moment correlations were computed between the informational questions, computer experience questions, computer hassles, and somatic complaints. An overall analysis revealed that the more computer courses a person had the lower the level of computer users' stress. It was found that the higher the number of computer hassles the higher the level of somatic complaints. The latter result is indicative of reactions to stimuli and situations evaluated as stressful. The sample was divided based on gender to perform mean difference analyses and correlational analyses. There were no significant mean differences between females and males for either computer hassles or somatic complaints. The correlational analyses revealed that gender moderates the relationship between computer hassles and somatic complaints. Females' level of computer hassles was significantly correlated ($r = .60$) with somatic complaints. For males the opposite was true; computer hassles were not significantly correlated ($r = .16$) with somatic complaints. The moderating effect of gender has been found in other stress research.

Abstracts

HEALTH SCIENCES

CONCERNS OF WOMEN EXPERIENCING A CHRONIC ILLNESS DURING PREGNANCY: A PRELIMINARY ANALYSIS. Sharon Hall, University of Alabama School of Nursing, University of Alabama at Birmingham, B'ham, AL 35294-1210.

Pregnancy has many transitional changes, both physiological and psychological. The psychological changes require the pregnant individual to use highly developed coping skills to adapt to this developmental milestone. What occurs when the stressor of chronic illness is added to the changes required to adapt to a normal pregnancy? What are the concerns of women who experience a chronic illness during pregnancy? How can health care providers assist the individual and her family to cope with these stressors? This study utilized a qualitative methodology to investigate these questions.

Women with Type I diabetes were interviewed to ascertain their concerns and coping strategies during pregnancy. Based on semi-structured interviews of eight women preliminary results indicated ten major categories. The categories covered such areas of concern as why they chose pregnancy, their knowledge base and source of knowledge, the actions of various health care professionals, and the feelings of the women, their husbands, their immediate families, and their co-workers. Additional categories included support systems, various physiological reactions, financial concerns, advice for others in similar situations, and their plans for future pregnancies.

The most interesting finding was that subjects reported actions were taken by the husband to ensure their wives were at minimal risk from sudden hypoglycemic reactions while the husbands were unavailable. A disturbing finding was the perception of minimal professional nursing input into the informant's routine visits to their physicians' offices.

CLINICAL IMPLICATIONS OF HYPOMAGNESEMIA. Crystal Harris and Robert E. Pieroni, Dept. of Internal Medicine, Univ. of Ala., Tuscaloosa, AL 35487

The importance of magnesium, an essential dietary mineral, is frequently overlooked by health care workers. This cation has been identified as a co-factor in more than 300 enzymatic reactions which involve energy metabolism, as well as protein and nucleic acid synthesis. Magnesium deficiency can result in numerous abnormalities, including severe weakness, seizures, cardiac dysrhythmias, as well as hypocalcemia and hypokalemia. Recently, we treated a middle-aged female with an extremely diminished serum magnesium level who presented with severe muscle spasms, low serum potassium and calcium levels, and cardiac tachyrrhythmias. We found the etiology of her chemical imbalance to be multifactorial, including abuse of alcohol and cathartics, as well as diuretic use. Her hospital course will be discussed, as will the pivotal role magnesium plays in maintaining appropriate homeostasis. The principle causes, effects, and treatment of hypomagnesemia will be described in detail.

Abstracts

A STUDY OF THREE FETOPLACENTAL MARKERS IN RELATION TO RACE, MATERNAL AGE, AND WEIGHT AND ESTIMATING DOWN SYNDROME. Larry R. Boots, Da-Chang Chu and Sue C. Bishop, Dept. of OB/GYN, The University of Alabama at Birmingham, Birmingham, AL 35294.

The detection of pregnancies associated with a Downs' affected fetus during the second trimester has changed dramatically over the past ten years. The least effective but also the oldest method was to perform an amniocentesis on women 35 years old or older and karyotype the fetal cells obtained. This method was effective but could detect no more than 20% of all Downs' affected fetuses. Currently, three markers, estriol, hCG and AFP are measured in the serum of the mother and by identifying an at-risk group, about 60% of such pregnancies can be detected. It is important, however, to carefully establish the normal characteristics of each of these markers in the region being tested and in relation to maternal age and weight and race. The purpose of this study was to determine these parameters for Alabama and to subsequently use these data to establish a prenatal screening program. The three markers were assayed in 852 blacks and 2370 whites ranging from 15-20 weeks of gestation. AFP levels for blacks increased from 32.7 ng/ml at 15 weeks to 67.7 at 20 weeks while for whites the range was 28.8 to 58.8. Similarly, hCG for blacks ranged from 49882 mIU/ml to 22340 and whites 36965 to 21125. Estriol levels for blacks were 0.75 ng/ml to 2.30 and for whites, 0.80 to 2.31. Significant correlations were also observed between maternal age and weight and each marker. These correlations will have to be factored into the calculations and considered when interpreting patient risk factors for Down syndrome.

HICCUPS: OCCASIONAL SEVERE CLINICAL IMPLICATIONS. Robert E. Pieroni, Dept. of Internal Medicine and Family Medicine, Univ. of Ala., Tuscaloosa, AL 35487.

Hiccups, or singultus, consists of spasmodic inhalations with closure of the glottis, accompanied by a peculiar characteristic sound. All of us have experienced hiccups at some time, and most episodes have been transient. Occasionally, individuals experience protracted episodes, and a variety of treatment modalities have been used with varying success. What is not well appreciated is that hiccups can occasionally signal a severe and/or potentially reversible disease state. For example, we have encountered hiccups as a presenting manifestation of diverse disorders, including severe hyponatremia, esophageal bleeding with gastric distention, and hepatic carcinoma. The literature has also associated singultus, sometimes intractable, with numerous other diseases, including Addison's disease, brain stem lesions, sarcoidosis, and brain abscess. We shall emphasize that hiccups is not always a benign phenomenon, and its presence may lead to early diagnosis of a panoply of disorders. Current clinical approaches to patients with singultus, including diagnostic and therapeutic interventions, will be described in detail.

Abstracts

MATH ANXIETY AMONG UNDERGRADUATE NURSING STUDENTS. Lynn M. Stover & Ellen B. Buckner, University of Alabama School of Nursing, Birmingham, Alabama 35294

Math anxiety has been identified as a problem for undergraduate nursing students, by both students and instructors. The purpose of this study is to determine the causes of and probable solutions for math anxiety among undergraduate nursing students. The convenience sample of 55 students included 9 males and 46 females with an age range of 19-50 years old. The subjects completed checklists to identify causes of and solutions for math anxiety, as well as the "Mathematics Anxiety Rating Scale" (MARS) to measure the current level of math anxiety. The mean MARS score, $\bar{x} = 219 + 64.4$, corresponded to the published mean for the tool, $\bar{x} = 215$. 76% of the subjects identified negative math attitudes and limited math backgrounds as probable causes of math anxiety. 89% of the subjects identified basic math review offerings as a possible solution to math anxiety. There was not a difference in the level of anxiety between males and females. There was a difference in the anxiety level of subjects who had previously experienced math anxiety and those who had not ever experienced math anxiety ($p < .001$) with previously anxious students scoring higher anxiety. The level of anxiety decreased as the student progressed in class level. Further research should be directed towards developing a tool which measures math anxiety specifically related to math encountered in the nursing profession, evaluating the effects of math review sessions in highly anxious students and determining changes in anxiety which occur in calculation of dosage exams.

RELATIONSHIP BETWEEN HOPE AND SELF-ESTEEM IN RENAL TRANSPLANT RECIPIENTS. Cassandra F. Warner, Organizational Development and Education, Univ. of Ala., Birmingham, AL 35233.

The purpose of this study was to ascertain if there is a relationship between hope and self-esteem in renal transplant recipients. The research hypothesis stated there was no statistically significant relationship between the two variables. Orem's (1985) self-care deficit theory of nursing provided the framework for the study. The study design was descriptive and the sampling technique was convenience. Instruments used were the Miller Hope Scale (MHS) and the Rosenberg Self-Esteem Scale (RSES). The sample consisted of 35 subjects--24 males and 11 females, who underwent first-time renal transplantation. Subjects' mean age was 36.6, and educational level ranged from 7 to 17 years. Scores were analyzed using the Pearson product moment correlation coefficient (Pearson's r). An alpha of 0.05 was set as the level of significance. The mean scores obtained for self-esteem and MHS were 30.182 and 164.286, indicating high levels of self-esteem and hope in the respondents. A statistically significant relationship was found between hope and self-esteem ($p = 0.0329$).

Abstracts

RELATIONSHIP BEWTEEN PERCEIVED STRESS, SOMATIC COMPLAINTS, SELF-ESTEEM, MOTIVATION, AND JOB SATISFACTION IN A COMMUNITY MENTAL HEALTH CENTER.
Pamela K. Ahrens and Richard A. Hudiburg, University of North Alabama, Florence, AL 35630

This study addressed the relationship between perceived stress, somatic complaints, self-esteem, motivation, and job satisfaction in a community mental health center. A questionnaire was administered to the 157 employees which consisted of informational questions (i.e., gender, age, job title, and length of employment) and several psychological scales, including the Perceived Stress Scale, The Hopkins Symptom Checklist, the Coopersmith Self-Esteem Inventory - Adult Form, the Work Environment Scale, and the Minnesota Satisfaction Questionnaire. Eighty-two employees responded to the questionnaire. As indicated by the pattern of significant correlations, those individuals who experience perceived stress tend to have a higher level of somatic complaints and lower peer cohesion. The intrinsic and general satisfaction of the employees were significantly correlated with the relationship and personal growth dimensions of their work environments. Intrinsic and general satisfaction was derived from the activity of the job itself and supervisor support. Extrinsic satisfying activities are performed for external rewards, such as pay and praise. The dissatisfaction that appeared with extrinsic satisfaction was in conjunction with pay, with the amount of pay received for the amount of work performed being most frequently marked as dissatisfying or very dissatisfying on 72.2% of the questionnaires. But extrinsic satisfaction ignored the fact that the employee could have been motivated by the job itself. Based on other research, it was expected that this study would show a significant correlation bewteen perceived stress and work pressure, but this correlation was insignificant ($r = .16$). It was also expected that the an employee with a higher level of self-esteem would have a greater satisfaction with the intrinsic, extrinsic, and general elements of their jobs. The results of this study were that self-esteem was insignificantly related to intrinsic satisfaction ($r = .05$), extrinsic satisfaction ($r = .12$), and general satisfaction ($r = .13$). On the basis of the results of this study, the employees at this community mental health center are more satisfied than the average professional.

DELPHI SURVEY TO IDENTIFY ATTRIBUTES DEEMED NECESSARY FOR FACULTY IN BSN PROGRAMS TO PROCLAIM CLINICAL COMPETENCE. Anne C. Smith, Director of Surgery, Oktibbeha County Hospital, Starkville, MS 39759.

A study was undertaken to identify attributes deemed necessary for faculty in BSN programs to proclaim clinical competence, using the Delphi technique. Knowles' adult learning theory was used as a theoretical framework. The study elicited a convergence of opinions from a panel of experts regarding items necessary for nurse educators to demonstrate consistently at the mastery level in order to proclaim clinical competence. The instrument used was a questionnaire compiled by the investigator. The focus of the questionnaire was on role model/nurse, transfer agent/teacher, and leader. Attributes consisted of specific knowledge, skills, and attitudes and values. Three rounds of questionnaires were used to gather the data. Round I had 52 respondents, Round II had 42 respondents, and Round III had 36 respondents, for an overall return rate of 35% of the population of nursing faculty teaching in NLN-accredited BSN programs in the state of Mississippi during 1990-1991. The semi-interquartile range and median for each of the 152 items were calculated. At the conclusion of Round III, there was consensus for 74 attributes deemed necessary for clinical competence. The participants selected 19 items related to knowledge, 25 items related to skills, and 30 items related to attitudes and values as "most relevant; mastery level demonstrated consistently."

Abstracts

CORRELATIONS BETWEEN THE PROTEIN-BOUND AND UNBOUND FRACTIONS OF ESTRADIOL AND TESTOSTERONE IN THE CIRCULATION. Tim Wood, H. Downing Potter and Larry R. Boots, Dept. of OB/GYN, University of Alabama at Birmingham, Birmingham, AL 35294.

Testosterone (4-androsten-17B-ol-3-one) and estradiol (1,3,5(10)-estratrien-3-17B-diol) circulate in blood bound to either albumin or sex hormone binding globulin (SHBG) or in an unbound state. Approximately 19% of testosterone and 30-40% of estradiol are bound to albumin, while 80% and 65%, respectively, are bound to SHBG and 1-2% of each hormone circulate free or non-protein bound. The non-protein bound fraction is generally considered to be the biologically active fraction while some studies suggest that the albumin-bound fraction may also contribute. Since both testosterone and estradiol bind to SHBG and because the free fractions of these hormones vary with age, sex and androgenic status, studies were initiated to determine the effectiveness of various determinates of sex hormone activity. In 255 patients, the following mean levels (± 1 S.D.) were obtained for : total testosterone, 100.2 ± 97.3 ng/dl; free testosterone, 0.9 ± 1.09 ng/dl; SHBG by method 1, $27.0 \pm 14.6 \times 10^{-8}$ moles/l; total estradiol, 102.4 ± 70.2 pg/ml; albumin bound testosterone, 43.4 \pm 16.3%; albumin bound estradiol, 54.1 \pm 29.4%; SHBG by method 2, $83.2 \pm 70.7 \times 10^{-9}$ moles/l; and SHBG by method 3, $45.5 \pm 43.3 \times 10^{-9}$ moles/l. These studies suggest that all three methods for assaying SHBG are highly correlated, but only the equilibrium dialysis method (method 1) for SHBG was significantly correlated with total testosterone levels.

CAMP NURSING FOR BSN STUDENT EXPERIENCES: PREPAREDNESS, AUTONOMY AND APPLICATION. Ellen Buckner, Elaine Marshall, University of Alabama School of Nursing, University of Alabama at Birmingham, Vicki Brannon, AMI Brookwood Medical Center and Cathy Caldwell, Baptist Medical Center, Montclair, Birmingham, AL.

Nursing in a camp setting was utilized for BSN student experiences with the following objectives: The student will be able to 1) Analyze published camp nursing standards to identify nursing responsibility 2) Participate in health screening of incoming campers 3) Assess, plan, implement and evaluate care including administration of prescribed medicine 4) Assess overall health and safety practices of the camp and review emergency policies 5) Integrate content from general assessment, pediatric nursing and community health nursing to design a plan of care for a selected camper problem.

Nursing diagnoses identified during the camp sessions included 1) Alteration in body temperature related to heat, increased activity and decreased fluid intake 2) Ineffective breathing related to hyperventilation (asthmatic child) 3) Susceptable to injury related to rough terrain, novel physical experiences and lack of safety awareness 4) Impaired social interaction related to homesickness and 5) Hostility and fighting behavior related to ineffective peer relationships. Positive nursing diagnoses in the developmental domain included enhanced strength and endurance and enhanced self esteem resulting from the camping experience.

Abstracts

MANAGERIAL ROLES OF MIDDLE NURSE ADMINISTRATORS IN BACCALAUREATE NURSING PROGRAMS. Patricia Kyzar, Univ. of N. Ala., Florence, AL 35630.

The purpose of this research was to describe and categorize the managerial roles of middle nurse administrators in baccalaureate nursing programs. A theoretical framework for this study was synthesized from Linton's role theory, Orem's general theory of nursing administration, and Mintzberg's managerial role theory. This descriptive research was implemented by mailing an investigator-constructed questionnaire for each middle nurse administrator in the 49 southern programs whose top administrators gave consent and agreed to distribute the questionnaires. Of 149 questionnaires sent to the 49 schools, 53 were returned after middle nurse administrators recorded on the questionnaires their managerial activities over a 5-day period. Self-reported activities were subjected to content analysis using Mintzberg's managerial role model in the framework as the categorization scheme. Out of 1,613 reported activities, all were categorized using all of the role groupings and roles except for 74 activities which were placed in an unnamed group. The most enacted role grouping was informational (863, 54%), followed by the interpersonal (405, 25%), and then the decisional (271, 16%) groupings. The most enacted roles were spokesman (626, 39%) of the informational grouping, leader (389, 24%) of the interpersonal group, and resource allocator (211, 13%) of the decisional grouping. Conclusions were that the synthesized theoretical framework can be used to describe, categorize, and guide managerial work and to guide graduate curricula and further research. Also, the priority of role enactment differs in nursing practice and nursing education.

PICA: PATHOPHYSIOLOGY AND CASE REPORTS. Christopher Kelley and Robert E. Pieroni, Dept. of Internal Medicine, Univ. of Ala., Tuscaloosa, AL 35487.

Pica is an eating disorder characterized by a craving for ingestion of substances that are unusual in kind or quantity. Children, for example, have developed lead poisoning from eating paint chips from older homes. A surprisingly large number of individuals of all ages habitually ingest certain types of dirt or clay (geophagia). Although this practice is worldwide, U.S. residents of rural Southern communities are more likely to practice pica, as well as one of its manifestations, pagophagia, i.e., excessive consumption of ice and iced drinks. Pica is often associated with iron deficiency anemia, sometimes of an extremely severe degree. The cause of the anemia is often unrecognized by clinicians. We shall present cases of pica among recent patients we have encountered and describe the history, treatment, and current theories of causation of both the underlying eating disorder, and its untoward and potentially lethal consequences. Since the practice of pica is frequently undiagnosed, health care workers must have a high index of suspicion when treating patients with anemia, lead intoxication, and a variety of other disorders which have been associated with pica.

Abstracts

CODEPENDENCY IN JUNIOR AND SENIOR NURSING STUDENTS. Portia Foster, College of Nursing, Jacksonville State Univ., Jacksonville, AL 36265.

A descriptive design was utilized to assess codependency in nursing students. The conceptual framework was derived from Roy's Adaptation Model and the concept of codependency. The purpose of the study was to examine codependency tendencies in junior and senior level nursing students. A convenience sample of forty-four students, aged 22 years to 39 years, was drawn from three classes in a baccalaureate nursing program. Three males and forty-one females participated in the study by completing two investigator-developed scenarios and a sixty item questionnaire. The hypotheses were tested using descriptive statistics. Junior and senior level nursing students viewed themselves as rescuers. From the findings, it was concluded that student nurses gave more of themselves than was required for effective care of patients. It was further concluded that the more dependent the patients were, the more giving the student nurses were. Implications from this study involve intervention planning and counseling needs. Nurses need to assess their codependency tendencies to identify adaptive and ineffective behaviors. It is recommended that studies be conducted to compare codependency traits in beginning level student nurses. It is further recommended that investigations be conducted to examine the differences in codependency tendencies between younger and older students. Additionally, studies conducted to compare variations in male and female nursing students codependency traits are recommended.

ADOLESCENT FEMALE ALCOHOL AND OTHER DRUG USE: THEMES AND PERCEPTIONS. Mary Bemker, Doctoral Student, University of Alabama School of Nursing, University of Alabama at Birmingham.

Research in the area of gender differences in alcohol and other drug use in adolescent populations tend to focus upon the substance preferred and the level of use. Using a semi-structured survey tool, based upon high risk characteristics designated in the Anti Drug Abuse Act of 1986, adolescent females were interviewed to determine what factors led to use or abstinence from alcohol and other drugs. The population pool for this study was adolescent females from multicultural backgrounds and mixed socioeconomic levels who were part of a state prevention program in the Southeastern United States. Major trends in responses will be discussed as well as ramifications for practice. Special thanks is extended to Dr. Charlene McKaig, faculty advisor- University of Alabama School of Nursing, for her guidance and support of this project.

Abstracts

BREASTFEEDING SUPPORT EMOTIONAL AND INFORMATIONAL AS RECEIVED BY MOTHERS DURING THE HOSPITAL POSTPARTUM STAY.

Lana D. Gatrey and Kelley Laird, Research Project Univ. of Ala. School of Nursing, University of Alabama at Birmingham, Birmingham, Alabama.

This study addressed the perceived emotional and informational support needs of new mothers during the first 2 hospitalized postpartum days. The study yielded a sample of 20 new mothers who delivered between 36 and 41 weeks gestation with the infants' Apgar score rating 8 or greater at 5 minutes of age. A 24-item questionnaire was administered to breastfeeding mothers. Ten items related to emotional support, with the remaining 14 relating to informational support. The subjects ranked the 24 support need statements according to perceived support. The calculated frequencies of responses to each statement enabled the investigators to rate the areas of greatest support and least support according to percentages. Based on the findings, it was concluded that new mothers perceive more informational support than emotional support. Recommendations are made for a similar study using demographic data, a rating scale with more diversity to responses, and an equal balance of questions to elicit responses. The researchers wish to express appreciation to the faculty members, families and friends who gave their guidance, assistance, cooperation, and support in writing this study.

BELIEFS OF EMERGENCY DEPARTMENT NURSES ABOUT BATTERED WOMEN. Freda L. Kilburn, R.N. DSN. Morehead State University, Morehead, KY 40351.

Current statistics indicate over 3 million women per year are beaten by their male partners. The literature indicates that emergency department personnel exhibit negativism, apathy, and attribution of blame toward these women. The purpose of this study was to determine the relationship between emergency department nurses' beliefs about battered women and their beliefs about women in general. Subjects were 247 registered nurses employed in 63 hospital emergency departments. Three self-administered questionnaires were used for data collection.

Abstracts

ENGINEERING AND COMPUTER SCIENCE

VISUALIZATION OF MECHANICS: A LOST ART? S.J. Vitton, Dept. of Civil Engineering, The University of Alabama, Tuscaloosa, AL 35487-0205.

In the age of "Computer Visualization" one must also ask the question "what about human visualization or better yet -- visual thinking". In two papers by Rudolf Arnheim; "Visual Thinking in Education" in *The Potential of Fantasy and Imagination* (Bradon House, 1979) and "A Plea for Visual Thinking" in *Critical Inquiry*, vol. 6 (Spring, 1980), Arnheim presents the need to develop students ability to think visually -- a skill that decreases with importance with increasing educational advancement. The critical argument put forth by Arnheim is that in effect thinking is visual and that while Western Society has separated the mental functions of perception and reasoning, they are in fact inseparable. According to Arnheim, visual skills, such as those developed through the arts are considered to be a lower cognitive function than for example reasoning skills, such as those developed through logic and courses in Mathematics; consequently, visual skills are neglected in higher education. If this is the case, one could then ask are visual skills important in understanding the fundamentals of mechanics? To address this question three examples are presented: (1) use of a slide rule versus a digital calculator, (2) understanding Mohr's circle for stress, and (3) understanding d'Arcy's Law of flow through a porous media. From these examples an attempt is made to show that visual skills are important in understanding mechanics and that in some cases simplified illustration used to aid in the understanding are in fact visually incorrect and distract from a students understanding. It is further augured that, paradoxically, the over use of visually imagery in teaching the fundamentals of mechanics, i.e., illustrations, graphs, at times may lead to decrease in a students ability to think visually and thus limiting the development of a more complete grasp of mechanics.

HYBRID NEURAL NETWORK IMPLEMENTATION OF STRATEGY SELECTION FOR SOLVING THE OBJECT-TARGET MATCHING PROBLEM. Vivek Anumolu, Dept. of Computer and Information Sciences; Norman W. Bray, Dept. of Psychology; and Kevin D. Reilly, Dept. of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL35294.

An "object-target matching" problem involves matching a set of objects with a set of targets in specified spatial relationship and temporal order. Bray et al. (in press) investigated the differences in strategy use between younger and older children in solving this problem. They observed that younger children frequently use simple strategies (e.g. pointing at objects) and older children frequently use advanced strategies (e.g., moving objects with orientation towards targets). A neural network model for strategy selection and evolution in this task is synthesized from known neural components and mechanisms such as sequential generators, associators, shunting excitation, and lateral inhibition. It is demonstrated that strategies evolve from the simple to the advanced based on accuracy and novelty bias criteria. In the neural network context, strategy use has the effect of uniformly boosting the activations of relevant item units, thereby increasing their probability of recall.

Abstracts

A STUDY OF THE PERMEABILITY OF BASE COURSE MATERIALS IN THE STATE OF ALABAMA. Jay Lindly and Ashraf El-Sayed. University of Alabama.

Excess water in pavement is the reason for many premature roadway failures. There are two ways to eliminate moisture-induced damage to pavement systems. The first one is to prevent the moisture from entering the pavement system, which is almost impossible. The other method is to drain the excess moisture, once it enters the pavement system, as quickly as possible. This method is dependent on the permeability of base and/or subbase layers in the pavement system. The more permeable the layer is the quicker it drains the excess moisture. However, a highly permeable layer could result in construction and rutting problems. For the last few decades, designers have used coefficient of permeability values based on charts presented by Cedergren, and more recently by using a chart presented by Moulton. Extensive laboratory testing was conducted using three different types base course materials in the state of Alabama. These materials were crushed limestone, crushed granite, and uncrushed river gravel. The testing was performed using different types of permeameters, and mainly used an apparatus developed by Barber and Sayer in 1952. The Barber/Sayer apparatus was designed to establish a laminar flow condition, and to eliminate soil particle migration. The laboratory work showed that eliminating the percentage of material over 3/4 inch in size has almost no effect on the measured coefficients of permeability. The laboratory work also showed that two different gradations with the same percentage of material passing number 200 sieve and the same dry density could have different coefficients of permeability. This observation will lead to a design of a new statistical model to predict aggregate permeability based on aggregate gradation. The continuing part of this research is studying the effect of untreated and asphalt treated large-sized aggregates on the coefficient of permeability, as well as trying to come up with the model mentioned above.

A FRAMEWORK FOR INTEGRATIONS OF FUZZY EXPERT SYSTEMS AND NEURAL NETS. Krishnamraju, P. V., Department of Computer and Information Sciences, The University of Alabama at Birmingham, Birmingham, AL 35294.

In this paper we attempt to develop an advanced intelligent hybrid system by integrating Artificial Neural Networks, Rule-Based Knowledge, and Fuzzy Logic paradigms. Combining these computational paradigms provide synergistic benefits and expands the application to which intelligent systems be applied. In this paper, we first propose an architecture which provides a framework for integration. Next, a method is given for mapping a fuzzy rule-based knowledge into a functionally equivalent neural architecture. A method to generate fuzzy rules from a trained neural net is also provided. Test results indicate that the neural network has the capability of handling a fuzzy rule base and that fuzzy rules generated from a neural network are both useful and usable within an expert system context.

Acknowledgements: The author wish to thank the following for their kind assistance with this project: Kevin D. Reilly, Yoichi Hayashi, and James J. Buckley.

Abstracts

DENOTATIONAL SEMANTICS FOR OBJECT ORIENTED LANGUAGES. Prakash Muthukrishnan. Department of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL 35294.

The objective of this research is to develop a formal semantics specification for C++, an object oriented language. Object oriented languages have requirements that can be summarized as:

$$\text{object oriented} = \text{data abstractions} + \text{object types} + \text{type inheritance}.$$

The most widely used approach to specifying the formal semantics of a language is denotational semantics. In denotational semantics, language constructs are modelled in terms of lambda calculus over strongly typed semantic domains. This effectively defines the language in terms of computable functions, with strong typing to ensure the correctness of those functions. A denotational semantics may be thought of as a mapping from a syntactic representation into a semantic one. We model inheritance (both single and multiple inheritance) and polymorphism in C++ language. The denotational semantics specification for this C++ subset contains both static and dynamic semantics; this can be used as a guideline during type checking of the compiler for the C++ subset language and also during code generation of the same. The code generated by the compiler can be executed by an ML interpreter.

Acknowledgement. This research was supported by a grant from the Alabama Academy of Science. I would like to thank my advisor Dr. Barrett R. Bryant for his guidance.

IMPLEMENTATION OF A RELIABLE AND USER FRIENDLY TUPLE SPACE INTERFACE.
Ramesh Dwarakanath, Dept. of Computer and Information Sciences, Univ. of Ala. at B'ham, AL 35294.

This interface provides a convenient front-end to Tuple Space, a network global storage space in which all the data is present in the form of tuples (consisting of key and content). The Tuple Space is logically divided into variable size partitions called subspaces. Processes attach themselves to Tuple Space according to the subspaces they reference. This interface simulates a Unix environment wherein the subspaces are treated as files and likewise the common utilities (cp, rm, mv etc) are applied to them. There is a list maintained in the Tuple Space which is persistent and accessible to every user of Tuple Space. This list contains filenames input by every application and their allotted subspace numbers. To achieve consistency among multiple users of the list there is a daemon program called manager-d which will regulate all the requests for subspace numbers. The problem of maintaining the status of Tuple Space at the time of crash/shutdown is taken care of by writing out the current state onto the disk.

Abstracts

OBJECT-ORIENTED REPRESENTATION OF LINGUISTIC KNOWLEDGE.
Li Li, Department of Computer and Information Sciences, The University of Alabama at Birmingham, UAB station, AL 35294.

This work is part of the ongoing research effort to develop a natural language interface to object-oriented databases (OODB). The linguistic knowledge for this purpose is separated into two parts: (1) the domain specific information is represented in a semantic network built on top of the OODB model in use; (2) the domain independent knowledge is formalized as a category hierarchy based on Category Grammar (CG). The conventional CG is augmented in two ways: firstly, each basic category is extended into a class which encodes the syntactic and semantic features common to all its instances and subcategories; secondly, the components of each functional category is treated as objects upon which various grammatical relationships can be specified as equations and established by unification. Ambiguous words are handled by multiple inheritance which assigns a constituent with different functions. This model offers the following advantages: (1) it provides an effective method to construct large and complex linguistic knowledge bases; (2) it supports robust and efficient parsing algorithms; (3) it is transportable and compatible in the context of OODB models. This research is supported by the Student Research Grant of Alabama Academy of Science

PARALLELIZATION ASPECTS OF C++. Viswanathan Vaidyanathan, Department of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL 35294.

A homogeneous blend of concurrent and object-oriented programming concepts provides a strong platform of multiple, interacting and concurrent objects. One way of achieving this is by adding explicit concurrency constructs to C++. This has been achieved by developing classes to model Actors which provide active objects. The different aspects to consider are the level of inter-object and intra-object concurrency, the types of synchronization constructs, the kind of message passing, and the issues in merging concurrency with inheritance. Another interesting research is to bring out the implicit concurrency in the object-oriented world. This involves the use of data dependence analysis and interprocedural dependence analysis to explore the concurrency between different methods within an object and also the dependency between different objects. The result of the dependency analysis yields information on the distribution of objects over a distributed or shared memory platform.

This research was supported by a research grant from the Alabama Academy of Science. Thanks also to my advisor Dr. Barrett R. Bryant.

Abstracts

ASYNCHRONOUS PRAM MODELS AND ALGORITHMS. Hiryoung Kim and Alan Sprague, Dept. of Computer and Information Sciences, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

As the need for parallel computation grows, many theories are focused on parallel algorithms and architecture. The PRAM (Parallel random access machine) is a theoretical model that corresponds to shared memory SIMD machine. It assumes that there is a global clock so that all processors execute in lockstep. Though the PRAM is helpful in theoretical studies of parallel processing, the PRAM algorithms are not efficient to be mapped onto MIMD machines which allow the processors to behave asynchronously.

There have been many studies in developing APRAM (Asynchronous PRAM) models and algorithms. In this study, we describe and compare three existing APRAM models: model 1 (by P. Gibbons), model 2 (by N. Nishimura), and model 3 (by C. Martel, R. Subramonian, and A. Park). All three models assume that there is no global clock and hence eliminate the PRAM's assumption of synchrony. The purpose of these models to develop APRAM algorithms that are as efficient as the PRAM's.

Model 1 explicitly charges synchronization cost and communication delay in measuring time complexity of its algorithms. Models 2 and 3 allow different interleavings of instruction streams. Model 3 also allows fault tolerance in that the model produces the correct result as long as there is one processor active.

Our concern is to study how these models affect certain algorithms. We study the proposed algorithms and develop algorithms for some problems for these models. We also study the efficiency of the algorithms by simulation. The task granularity is a function of unreliability and cost of communication. We investigate how efficient these models are according to grain size.

HAVE ALABAMA MUNICIPALITIES BEGUN REQUIRING CONSISTENT STORM-DISCHARGE NON-AGGRAVATION FOR LAND DEVELOPMENT? James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205

The national philosophy for the management and gradual diminution of damage caused by flooding has been to study the waterways of the nation to define flood-prone areas, to prohibit the building of damageable structures in those areas, and to provide in jurisdictions that adopt suitable management regulations a program of subsidized flood insurance for such structures already in the areas until their useful life has been concluded. One feature of such local regulations is that new development should not cause aggravation of prevailing peak runoff rates. The author reports upon the extent to which his studies indicate that Alabama municipalities have begun to enforce such requirements.

TWO PATH PROBLEM ON INTERVAL GRAPHS. Sridhar Natarajan and Alan Sprague, Dept. of Computer and Information Sciences, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

Given a graph $G(V, E)$, and vertices s_1, s_2, t_1 , and t_2 of G , the two path problem is to find two paths one from s_1 to t_1 and the other from s_2 to t_2 . We provide $O(|V|)$ algorithm for the vertex disjoint version of the two path problem on interval graphs, where s_1, s_2 are adjacent and t_1, t_2 are adjacent. Given the interval model for an interval graph, the algorithm uses a scan line approach to construct the two paths if they exist.

Abstracts

AN INTEGRATED THEORY FOR SUSPENDED-GROWTH BIOSCRUBBERS.
Hsien-cheng Chang and Stan Vitton, Dept. of Civil Eng., Univ.
of Ala., Tuscaloosa, AL 35487-0205.

Biodegradable volatile organic compounds (VOCs) can be mineralized by biological methods. Among those biological treatment methods, the suspended-growth bioscrubber has the apparent advantages of less pressure loss and better control than biofilters and fixed-film bioscrubber. The suspended-growth bioscrubber consists of an absorber and an external microbial oxidation reactor. In this study, a computer simulation model was developed to explore the variation of removal efficiency with different values of microbial kinetic parameters, Henry's Law constant, volumetric mass transfer coefficient and system configurations. For the system modeled, the simulation showed that the microbial parameters had only small effects on the removal efficiency. Henry's Law constant, volumetric mass transfer coefficient, recirculation liquid flow rate, and gas flow rate were the major parameters in determining the removal efficiency.

THE RE-DISCOVERY OF THE SHOULDER-TOP COMPUTER AS A PRIME TOOL IN MIDDLE SCHOOL SCIENCE TEACHING. Ernest D. Riggsby and Joseph D. George, Columbus College, Columbus, GA 31907-2079.

With growing technology and increasing dependence upon the vast array of hardware and software, it becomes easy to neglect or passover the immediate potential of a low-tech, long ago discovered, powerful tool for problem solving, the shoulder-top computer. This versatile instrument was re-discovered and re-adapted to the full range of middle school science teaching. Most emphasis was placed upon problem solving and thinking skills from simple computation to higher order protocols.

Concurrency Control Mechanism for CORAL (Concurrent Object-oriented Applications Language). Chandrasekaran Venkatapathy, Dept. of Comp. and Info. Sciences, Univ. of Ala. at B'ham, AL 35205.

Concurrent Object oriented Applications Language (CORAL) is being developed by IBM. It is an environment for parallel and distributed applications. It provides facilities for manipulation of concurrently accessed data or distribution of data over a network of heterogeneous computer systems. For concurrent access of data, a good concurrent control mechanism is needed to provide consistency. The objective of this work is to find a suitable concurrency control mechanism for CORAL. Thanks to Dr. Barrett R. Bryant for his help and guidance.

Abstracts

HOW WILL THE NEW FEDERAL REGULATIONS FOR MUNICIPAL SOLID-WASTE LANDFILLS AFFECT SOLID-WASTE MANAGEMENT IN ALABAMA?
L. Faye Jones and James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205 and Lorna A. Greening, Ph.D., Division of Research and Service, College of Commerce & Business Administration, Univ. of Ala., Tuscaloosa, AL 35487-0221

The U.S. Environmental Protection Agency (EPA) has promulgated new regulations concerning the landfill disposal of municipal solid waste (MSW). Major portions of these regulations, commonly referred to as subtitle D, will become effective on 9 October 1993, forcing the closure of some landfill sites, the modification of others, and the construction of new sites. Because of the high costs for construction and operating a subtitle-D landfill, the trend nationally and in Alabama is to move away from a large number of low-volume MSW landfills to a smaller number of multi-county , high-volume regional operations which may be controlled publicly or privately. The authors report on some of the changes which are occurring in solid-waste management in Alabama as the result of the new regulations. This study was funded by a research grant from SOMED (School of Mines & Energy Development, the University of Alabama).

HYBRID NEURAL NETWORK IMPLEMENTATION OF STRATEGY SELECTION FOR SOLVING THE OBJECT-TARGET MATCHING PROBLEM. Vivek Anumolu , Dept. of Computer and Information Sciences; Norman W. Bray, Dept. of Psychology; and Kevin D. Reilly, Dept. of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL35294.

An “object–target matching” problem involves matching a set of objects with a set of targets in specified spatial relationship and temporal order. Bray et al. (in press) investigated the differences in strategy use between younger and older children in solving this problem. They observed that younger children frequently use simple strategies (e.g. pointing at objects) and older children frequently use advanced strategies (e.g., moving objects with orientation towards targets). A neural network model for strategy selection and evolution in this task is synthesized from known neural components and mechanisms such as sequential generators, associators, shunting excitation, and lateral inhibition. It is demonstrated that strategies evolve from the simple to the advanced based on accuracy and novelty bias criteria. In the neural network context, strategy use has the effect of uniformly boosting the activations of relevant item units, thereby increasing their probability of recall.

Abstracts

INTEGRATING FUNCTIONAL, LOGIC AND OBJECT-ORIENTED PROGRAMMING PARADIGMS. Zeki Bayram, Computer and Information Sciences Department, University of Alabama in Birmingham, AL 35294.

A method of integrating Functional, Logic and Object-Oriented programming paradigms based on transformations is presented. The resulting combined paradigm permits symbolic manipulation of complex objects in a Functional/Logic context. Functional/Logic programs are generally very concise and expressive. They also have a declarative reading based on logic and equality. Complex objects, on the other hand, are necessary to authentically and naturally model the real world. By combining these paradigms, we are providing for declarative representation of the real world. Operationally, our method assumes the existence of an object-expression evaluator and relies on transformations and calls to this object-expression evaluator as its means of computation. Programs of the combined paradigm consist of conditional rewrite rules augmented to incorporate object expressions.

Abstracts

ANTHROPOLOGY

THE PARDO STONE: A GENUINE ARTIFACT? Bill Reid, Department of Physical Sciences and Engineering, Jacksonville State University, Jacksonville, AL 36265.

In 1934, Mr. Bryson Hammett on his farm west of Inman, SC, in Spartanburg County, plowed up a shaped stone of soft granite. It bore incised on it a left-pointing arrow, a rising (setting) sun, the (presumed) date 1567, and two parallel horizontal lines enclosing a rectangle with two diagonals, similar to a cross of St. Andrew. The stone is now prominently displayed in the Spartanburg County Museum. Juan Pardo carried out two expeditions into the back country from the Spanish settlement at Santa Elena, thought to be near today's Beaufort, on the South Carolina coast. On his first expedition in 1566, a letter reached him in the back country, seemingly implying that he had left route markers. Leaving a fort and two different contingents of men, he returned to the coast. In 1567, he again penetrated the back country. There is no consensus concerning his route, but most writers seem to agree a sizable portion lay within the present state of South Carolina. Curiously, the then Spanish Flag consisted of an unusual version of Saint Andrew's Cross called the raguly saltire. The 1567 date and the St. Andrew's Cross argue strongly for this stone as a relic of the second Pardo expedition. A traveler in the South Carolina back country in 1725 mentioned a fort of unknown origin on the Cherokee Path in nearby Greenwood County, which stood near another "Pointing Rock". The whereabouts of this fort and rock is not known today. A 1760 legend describes a lost silver mine worked by Spaniards years before, also in the same locale. One yearns for additional detail to emerge from some library or archive, or the recovery of the site, but the possibility seems remote.

DELUNA'S COOSA REVISTED. Harry O. Holstein, Professor, Dept. of Geo./Anthro., Jacksonville State Univ., Jacksonville, Ala. 36265.

Since 1989 a group of researchers have focused archaeological research to the area of the confluence of the Chattooga and Coosa Rivers in the Weiss Basin of Northeast Alabama. A cluster of protohistoric sites have yielded supportive evidence to indicate this locale represents portions of the 16th Century principle town of Coosa. This data comes from previous archaeological investigations, recent collections and the analysis of earlier excavated materials.

Abstracts

ARCHAEOLOGY OF OLD FRENCH MOBILE. Gregory A. Waselkov,
Dept. of Sociology & Anthropology, Univ. of S. Ala.,
Mobile, AL 36688.

Since 1989, archaeologists from the University of South Alabama have been surveying and excavating the site of Old Mobile (1MB94), the capital of French colonial Louisiana from 1702 until 1711. This site is the first European town established in Alabama. An intensive shovel testing survey has led to the discovery of 43 colonial structures, to date. Seven of these have been completely or partially excavated, including six domestic dwellings and a blacksmith's shop. Apart from French artifacts dating to the early 18th century, many artifacts of Spanish colonial origin have also been recovered. These indicate extent of trade between Old Mobile and the Spanish towns of Pensacola, Havana, and Veracruz, necessitated by inadequate supply lines to France. Indian artifacts are also extremely abundant, especially pottery made by Indians for Europeans. These "colono" ceramics were manufactured in traditional Indian ways, but they resemble European plate, bowl, and mug forms. Continuing excavations at Old Mobile are also revealing architectural evidence of the first "creole-style" houses built in the South, as well as indications of long-distance trade for lead ore (galena) and red pipestone. Archaeology is providing a new perspective on the early historic period of Alabama and the Gulf coast.

DONALD MCKAY'S U.S.S. ESSEX. Steven R. Hack, Panamerican Consultants Inc., Tuscaloosa, Alabama 35404.

Lake Superior holds the only remains of a sloop-of-war built by Donald McKay. The U.S.S. Essex, a wooden screw sloop, is evidence of the final years of the U.S. Navy's "Dark Ages." After the Civil War many vessels were laid up, never to be used again. McKay made his name by constructing the fastest clipper ships the world has ever known. At the end of McKay's era the U.S. government contracted him the building of two ENTERPRISE class sloops-of-war, Adams and Essex. In 1873 the Essex started its career and sailed to various "hot spots" around the world. In 1904 she became a training vessel for the Naval Reserve on the Great Lakes and was finally stricken from the Navy list in 1930. She was sold, stripped, and burned for her metal, ending her 57 year service. In early spring 1992 investigations of the wreck site found the remains to consist mainly of a 50 foot portion of bottom hull including keelson, rider keelson, sister keelson, hull and ceiling planking. The remains show it to be heavily fastened with a variety of drift bolts and ironwood (lignum vitae) plugs. It was also noted that from the combination of souvenir hunters and Mother Nature, one of Donald McKay's last vessels ever built will be destroyed.

Abstracts

ARCHAEOLOGICAL SURVEY OF 11 METHANE GAS WELLS, TUSCALOOSA AND GREENE COUNTIES. Matthew D. Hartzell, Panamerican Consultants, Inc. Tuscaloosa, Alabama 35404.

The primary goal of this presentation is to emphasize the discovery of three sites, each of different cultural affiliations, within a two-mile radius in Tuscaloosa County, Alabama. Inherent in the breakdown of these cultural sites, 1Tu673, 1Tu674, and 1Tu675 is that diagnostic material enabling cultural differentiation was located at all three sites. The discovery of both round and square nails at historic site 1Tu673 suggests an early 20th Century European-American occupation. Meanwhile, the collection of a Baytown Plain potsherd with dense amounts of lithic material at 1Tu674 indicates a Late Woodland aboriginal affiliation. On the other hand, location of a Kirk corner-notched PP/K, sans potsherds, at 1Tu675 suggests an Early Archaic aboriginal affiliation. Unfortunately, previous impacts such as logging, agriculture, and associated roadbuilding have been central in altering the depositional integrity of these sites and thus negating the feasibility of future study. However, these findings of diagnostic materials allow accurate inferences as to these locations' periods of occupation.

THE 1992 ARCHAEOLOGICAL PEDESTRIAN SURVEY OF PORTIONS OF NORTHEAST ALABAMA. Thomas E. Chappelow, Student, Jacksonville State Univ., Jacksonville, Ala.

During the spring and Summer of 1992 an archaeological survey of portions of Lookout Mountain was conducted by Jacksonville State University. This survey was made possible through a grant from the Alabama Historical Commission. Survey area included those portions of Lookout Mountain which lie in Cherokee, Dekalb and Etowah counties. As a result of this project, fifty-two cultural resources were recorded in an area which had previously received little investigation attention to this kind. Both historic and Aboriginal sites were documented. Aboriginal presence in the area was documented from Paleo through Late Mississippian time periods and appears to have been most concentrated during Archaic and Woodland periods of prehistory.

ARCHAEOLOGICAL STATUS IN ALABAMA. Gregory C. Rhinehart, Chief, Planning and Protection Division, Alabama Historical Commission, Montgomery, AL 36130

This paper focuses on the current status of professional archaeology being conducted in the state and the way the state is using Federal laws and State legislation to help control the looting of sites.

Abstracts

TECHNOLOGY AND ARCHAEOLOGY: TOTAL STATION USE IN TERRESTRIAL AND UNDERWATER APPLICATIONS. Robert T. Rice, Panamerican Consultants, Inc., Tuscaloosa, Alabama 35404.

For archaeologists, whether excavating aboriginal sites or recording sunken historic wrecks, data collection is the prime objective during the field portion of any investigation. State of the art surveying equipment, used in conjunction with personal computers, make the collection, storage, retrieval, and practical use of this data faster and easier than has been the case with older surveying methods. User defined sequences can now be custom programmed to provide the operator with applications for practically any imaginable field problem. The memory, or "electronic fieldbook", is used to store data recovered which is down-loaded to a personal computer. Optional programs then translate this raw data into a usable form, such as topographic maps and traverse lines for magnetometer and sonar surveys. Specific points entered into the memory of the total station can be recalled in the field for baseline grid or traverse line construction. This paper will discuss how this technology has been successfully used during terrestrial and underwater investigations conducted by Panamerican Consultants, Inc.

THE NAVIDAD RIVER WRECK (41-JK-9): HISTORICAL AND CONSTRUCTION ASPECTS OF AN EARLY STEAM VESSEL OF COMPOSITE CONSTRUCTION. Charles E. Pearson, Coastal Environments, Inc., Baton Rouge, Louisiana 70802. James A. Duff, Panamerican Consultants, Inc., Tuscaloosa, Alabama 35404.

In September 1991 an underwater cultural resources study incorporating historical research, remote-sensing, and diving was conducted along sections of the Lavaca and Navidad rivers in Jackson County, Texas, for the U.S. Army Corps of Engineers, Galveston District. Performed by archaeologists with Coastal Environments, Inc. of Baton Rouge, Louisiana and Panamerican Consultants, Inc., of Tuscaloosa, Alabama, the investigation identified the remains of two sunken vessels, one of which represents the well preserved remains of an early composite-built sidewheel steamboat. While its identity is unknown, available oral and documentary histories indicate that the steamer, which has an iron hull and wooden longitudinal timbers, was abandoned during the Civil War. This paper focuses on the vessel's unique construction characteristics, as well as the oral history that surrounds one of the earliest iron sidewheel steamers found in Texas waters.

Abstracts

CENTRAL PLANK ROAD: MONTGOMERY TO WINTERBORO. Phillip E. Koerper, Department of History, Jacksonville State University, Jacksonville, AL 36265

The Central Plank Road, was constructed by John G. and Joseph G. Winter in 1850-51 and was utilized until 1862. The original plan was to build the road to Guntersville but the terminus became Winterboro because of disputes with some communities on the route, unexpected construction expenses and competition from railroad expansion. Toll receipts from the Central Plank Road were disappointing because state regulations exempted many types of traffic on the road. The Central Plank Road was constructed on 4 x 6 wooden stringers covered by 2 x 6 planks and was ten feet wide. The Central Plank Road ultimately failed because of bankruptcy in the Winter family, insufficient tolls, costly repairs and competition with railroads and better constructed roads.

PREHISTORIC SETTLEMENT PATTERN CHANGE IN CENTRAL OKTIBBEHA COUNTY, MISSISSIPPI. Terry Lolley, Panamerican Consultants, Inc., Tuscaloosa Alabama, 35404

This study focuses on determining if there was a shift from nucleated to dispersed settlement patterns from the Woodland through Protohistoric periods in central Oktibbeha County, Mississippi, and to examine the spatial organization of the sites. A shift from nucleated to dispersed settlements is often placed at the end of the Mississippian period, but these data indicate it occurred much earlier.

Collections from 31 sites were analyzed, and the results showed major settlement pattern changes first in the Late Woodland period, from nucleated to dispersed, then in Mississippian, scattered to clustered, and then in Protohistoric, to eroded upland chalk soils.

PRELIMINARY INTERPRETATIONS OF THE MICROLITHIC DATA FROM THE BOTTLE CREEK SITE. Paul D. Jackson, Panamerican Consultants, Inc., Tuscaloosa, Alabama 35404.

This study focuses on the preliminary research on the microlithic data collected from the Bottle Creek site in Baldwin County, Alabama. The main objective was to collect and analyze the lithic raw data and hopefully draw some conclusion as to whether the microlithics had a significant use, and what they were being used to make.

Collections from two units on Mound L at Bottle Creek were analyzed. The results showed there was production and use of microdrills during the different stages of Mound L. The question still remains as to what the microdrills were used to make.

Abstracts

OBJECTIVE JAIL CLASSIFICATION: AN IMPORTANT CHANGE. William E. Osterhoff, Dept. of Justice and Public Safety, Auburn Univer. at Montgomery, Montgomery, AL 36117.

A primary responsibility of the nation's jails is to safely and securely detain individuals remanded to their custody. Classification of offenders is a primary management tool used to accomplish this function by matching custody and program needs of offenders with appropriate security levels of the institution.

Jail offender population are characteristically heterogeneous, yet classification decision often must be made quickly with little information about the individuals being processed. In most cases, jail classification decisions in the past have been subjective, with limited reliability and validity. A tendency toward "overclassification" (higher custody and security assignments than are actually necessary) has contributed to jail overcrowding and related problems, including assaultive behavior, disciplinary infractions, suicides, and escapes. In addition, federal and state courts have viewed subjective and arbitrary inmate-related management decisions unfavorably.

Objective jail classification use standardized screening and classification instruments and procedures to determine inmates' custody and/or program needs. Staff expertise and judgement are used to review objective classifications recommendations and can result in classification adjustments subject to supervisor concurrence. Additive point scales or decision trees are the most frequently used classification techniques.

An objective classification system endorsed by the National Institute of Corrections includes an inmate screening form, inmate custody assessment and reassessment scales, an initial inmate needs assessment form and an inmate needs reassessment form. Emphasis is placed on monitoring and evaluating the classification procedure to maximize reliability and validity of classification decisions by adjusting cut-off scores as necessary.

MINUTES

ALABAMA ACADEMY OF SCIENCE
SPRING EXECUTIVE COMMITTEE MEETING
BEVILL CENTER 267
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE
MARCH 24, 1993

- A. Dr. Michael Moeller, President of the AAS, called the meeting to order at 8:40 p.m. The minutes of the October 10, 1992, Fall Executive Committee Meeting were approved with two corrections.
 - 1. Added the approval of a resolution concerning animal rights which had been omitted.
 - 2. Delete the statement concerning passing an amendment for the Mason Scholarship.
- B. Officers' Reports
 - 1. Board of Trustees - Dr. Barker noted that four members of the Board of Trustees were present but made no further report.
 - 2. President - Dr. Michael Moeller submitted the following:

The current state of the Academy is very good. In my opinion we have no major problems. I believe our weakest area is a problem of low visibility.

- 3. President-Elect - Dr. Prakash Sharma presented the following:

The following activities are reported on. The activities involve not only my efforts, but those of a number of others, as well.

- *Engaged in numerous discussions with sectional chairs and vice-chairs.
- *Conferred to seek and give advice to Dr. Michael Moeller, President, Alabama Academy of Science on numerous occasions.
- *Exploring ideas to solicit more manuscripts for the Journal of Alabama Academy of Science. Had been in constant touch with Dr. James Bradley, Editor, the Journal of Alabama Academy of Science. The Editor encountered problems in identifying suitable reviewers for submitted manuscripts. I have contacted two physicists to submit invited review articles in their areas of specialization.

- 4. Second Vice-President - Dr. Eugene Omasta reported as follows:

The nominating committee, by telephone, has discussed all appointed officers whose terms expire in 1993. Nominees for all of these positions will be presented at the business meeting on Friday, March 26, 1993.

Minutes

A telephone poll of all volunteers in the Visiting Scientist program is planned during May, 1993 to gather data on both participation in the program and recommendations for improvement.

We look forward to hosting the annual joint meeting of the Alabama Academy of Science and the Alabama Jr. Academy of Science at the Troy State University main campus next year.

5. Secretary - Dr. Larry Boots submitted the following:

Secretary's Report - March 24, 1993

Membership as of April 22, 1992	728
Members dropped for non-payment of dues	
Regular members	-125
Student members	-51
New Members added	<u>109</u>

Total membership as of March 24, 1993	661
(net change since April, 1992)	(-67)

Trends in Membership	<u>Members</u>
March 1989	905
March 1990	912
October 1990	767
March 1991	872
September 1991	980
April 1992	728
March 1993	661

MEMBERSHIP BY SECTION

<u>Section</u>	<u>1991</u>	<u>April 1992</u>	<u>March 1993</u>
I. Biological Sciences	238	155	168
II. Chemistry	90	82	77
III. Geology	41	25	23
IV. Forestry, Geography, Conserv., & Planning	25	21	28
V. Physics & Math	96	76	69
VI. Industry & Economics	42	29	23
VII. Science Education	38	27	27
VIII. Social Science	54	25	27
IX. Health Sciences	137	101	93
X. Engineering & Computer Science	59	44	31
XI. Anthropology	21	13	13

Minutes

99. Industry, Politician, etc.	22	13	2
77. Libraries - University	26	26	22
88. Libraries - High Sch.	50	50	51
99. Unknown	3	3	7

MEMBERSHIP BY TYPE

	<u># IN 1991</u>	<u>1992</u>	<u>1993</u>
Individual	468	523	461
Student	69	89	77
Emeritus	22	21	23
Life	18	19	21
Honorary	6	4	4
Sustaining/Individual	6	4	4
Sustaining/Organization	1	0	0
Library/University	29	26	22
Library/High School	50	48	51

6. Treasurer - Dr. Larry Krannich submitted the following report:

The Treasurer's Report consists of copies of the following:

ACCOUNT BALANCES as of 12/31/92 and 1992 Treasurer's Report (1/1/92 through 12/31/92) --- This portion has been omitted. It can be obtained by contacting either the Secretary or Treasurer.

ACCOUNT BALANCES REPORT as of 3/22/93 and 1993 Treasurer's Report (1/1/93 through 3/22/93).

ACTIVITIES relative to 1993 Budget.

During calendar year 1992, we collected approximately \$1,500 less in dues than we projected in the budget. About 60% of the dues were collected in the last quarter. Mason fund scholarship income was \$1,300 more and expenditures were approximately \$2,000 less than projected in the budget. Annual meeting expenses were \$300 less, executive director expenses were \$600 less, journal expenses were \$600 less, officer expenses were \$1,000 less, and recruiting brochure expenses were \$600 less than projected in the budget. We ended the year expending \$6,000 less than projected, but with a net income of \$1,000 over expenses. This net income is somewhat misleading due to a cash flow problem. To avoid having to cash a CD to cover expense commitments for the Junior Academy of Sciences and the Science Fair, these 1992 expenses were deferred until 1993. They have now been paid and are reflected in the 1993 expenditures. We ended 1992 with a reserve of \$57,196.28 in total assets.

Minutes

The 1993 activities are in keeping with our approved 1993 budget.

7. Journal Editor - Dr. Jim Bradley prepared the following report:

This report covers the four issues of the Journal of the Alabama Academy of Science published since the 1992 meeting of the Academy. These are Vol. 63 (No.2, 3 and 4) and Vol. 64 No. 1. The latter issue is presently in press.

During this period, 13 manuscripts were submitted for publication. Ten of these have been accepted for publication, and two are still in the review process. I was pleased to publish five manuscripts from last year's symposium on Drugs of abuse. The response to October's issue where three of these articles appeared has been very positive, and I hope to have an issue in 1993 devoted to the symposium on Zebra Mussel Infestations. One review article was received and accepted for publication after last year's call for review articles.

In 1992, 245 abstracts from the annual meeting were published. This is up from 213 published in 1991.

I encourage the membership to submit more manuscripts to me, especially review articles suitable for a wide readership.

8. Counselor to AJAS - Dr. Bateman presented his report:

The Alabama Junior Academy of Science has a full schedule of activities planned for the annual meeting, including: the paper competition among 45 regional winners, local tours, the caucus and the election of state officers, presentation of awards, the joint banquet with the movie, and the Saturday rap session with our banquet speaker, Dr. Gore.

At this time, 126 students and sponsors have pre-registered for the meeting and 124 plan to attend the joint banquet.

9. Science Fair Coordinator - In the absence of Mrs. Mary Thomaskutty, Dr. Omasta reported briefly that weather problems had affected some regional fairs but everything was progressing favorably.

10. Science Olympiad Coordinator - Steven Carey presented the following:

The Alabama Science Olympiad is currently divided into six regions. A list of host institutions, regional coordinators, and tournament dates for 1992-93 is attached. All regions host Division C (grades 9-12) Science Olympiad tournaments; three host Division B (grades 6-9) olympiads. Presently, there is no Division A1 (grades K-3) or Division A2 (grades 3-6) regional tournaments; however, a regional Science Olympiad for elementary students at Auburn University is in the planning stage. Winners at the regional Division B and Division C olympiads advance to the State Science Olympiad to be hosted by the University of Alabama at Birmingham. State winners in both divisions advance to the National Science Olympiad to be hosted by the University of Southern Colorado in Pueblo on May 21-22.

Minutes

In 1993, 46 Division B and 88 Division C teams, involving approximately 2000 junior high and high school students, competed in regional Science Olympiads. Nine Division B and 18 Division C teams will compete at the State Science Olympiad.

Alabama was one of five states that field tested a proposed new Science Olympiad event called Earth Process Lab. Input concerning this event will be collected by the State Science Olympiad Director and presented at the annual Science Olympiad State Directors meeting in Pueblo.

The Science Olympiad is a volunteer effort and everyone who gives of their time and expertise to make this program a success deserves the thanks of the Academy.

11. Counselor to the AAAS - no report.
12. Section Officers:
 - I. Biological Sciences - Dr. James McClintock prepared the following:
 - 1) I am pleased to announce that we have even more presentations and posters which will be presented at this year's Huntsville meetings than last year. A total of 60 papers and posters are planned!
 - 2) I would also like to remind everyone that our President, Dr. Mike Moeller, along with Dr. Terry Richardson and Dr. Richard Modlin, have gone to great lengths to organize an exciting and timely symposium on Zebra Mussel Infestations. This symposium, featuring invited scientists from around the country and Canada, will take place Friday afternoon, March 26, at 1:25 p.m. in the Science Building, Room 127. Please plan to attend and pass the word to your colleagues and students!
 - II. Chemistry - no report.
 - III. Geology - no report.
 - IV. Forestry, Geography, Conservation & Planning - no report.
 - V. Physics and Mathematics - no report.
 - VI. Industry and Economics - no report.
 - VII. Science Education - no report.
 - VIII. Behavioral and Social Sciences - Dr. Richard Hudiburg submitted the following:

In order to encourage participation in this years' program, I contacted current and former members of this section by letter. This effort did not yield the desired result. Only eight papers are scheduled for the 1993 meeting. In response to the low number of papers, the Behavioral and Social Sciences Section will set a goal for 1993-94 to increase section membership and participation in the 1994 annual meeting.

Minutes

- IX. Health Sciences - no report.
- X. Engineering and Computer Sciences - no report.
- XI. Anthropology - no report.

13. Executive Officer - Dr. Leven Hazlegrove submitted the following report:

Since the Fall Executive Meeting, October 10, 1992, SRI, we have been working on the following projects during the last 5 months:

- 1) Assisted with the ASTA Meeting at the UAB Arena in September 10-11, 1992, by facilitating the delivery of 150 Visiting Scientists' Directories under Dr. Eugene Omasta's direction and the help of Dr. Moeller and Dr. Bateman, Dr. Barrett, and Dr. Sharma, and follow up of same.
- 2) Supervised payment of the third Mason Fellowship to Mrs. Joni Justice Shankles (Samford University) who is working to complete the MAT by July, 1993. This means \$6,000 spent out of current income where the Mason Scholarship Committee recommended spending only interest from the "Mason Corpus".
- 3) Computerized the Gorgas Scholarship Foundation, Inc., Science Talent Search in cooperations with the Westinghouse Scholarship Ranking at the UAB meeting, March 24-27, 1993, and with the leadership of Dr. Glynn Wheeler, Sect. Treasurer.
- 4) Mailed by bulk mail nearly 800 Newsletters edited by Dr. Ricketto, Fall, 1992.
- 5) Supervised the judging at UAH of the Westinghouse and Gorgas Scholarship Foundation, Inc., finalists ranking the top ten of Alabama (see AJAS Report) March 26, 1993, with Dr. Dave Cole, Director.
- 6) Development of letters to 12 industrial companies and foundations with positive reply from four. Dr. Moeller did an excellent job with this, collecting nearly \$1,000 for AJAS.
- 7) Worked with Dr. Barker's Committee several hours Saturday, January 30, 1993, regarding finances that have to be "husbanded" carefully!
- 8) Met with Dr. Modlin, Chairman of the Local Arrangements Committee, UAH, several hundred times on the telephone and 198 letters with Dr. Omasta, Dr. Moeller, and Dr. Bateman.

Minutes

- 9) Assembled, edited and bulk mailed 700 UAH programs on February 22, 1993, with Dr. Barrett's able assistance.
- 10) Checked carefully (with Ms. Sonja Ruff's leadership) our "non-paying" members that plan to give papers at UAH, March 24-27, 1993.

C. Committee Reports

1. Local Arrangements - University of Alabama in Huntsville- Dr. Richard Modlin reported that everything was in place and except for a few minor room changes, no problems were foreseen.
2. Finance - A portion of Dr. Barker's report follows. The complete text may be obtained from the Secretary or Editor.

When the Academy Finance Committee met on 30 January 1993, we were delighted to receive the Treasurer's report for the full year of 1992 showing that an anticipated deficit of several thousand dollars had been turned around into a balance of \$1,000. However, Dr. Krannich pointed out that we had spent \$6,000 less than called for in a realistic budget for 1992, and that we could expect to see several sizable items show up in 1993.

Sure enough, when you see his report for the first quarter of 1993 (10 days short of a full 3 months), we have already acquired an \$1,800 deficit - and the worst may be yet to come. The explanation, if you want one, can be found in a careful study of the Annual Treasurer's Report (for instance, of 1992) broken down into quarters. Without wasting time on details, income varied from a high of \$14,000 in the last quarter to \$22 in the second quarter, and expenses from \$3,000 to \$10,000 in the same two quarters respectively.

3. Membership - no report.
4. Research - Dr. Tom Jandebeur gave the following report:

Student Research Award Competition: Fifty students requested applications for entering the Competition; 39 followed through with completed applications prior to the deadline set for publication of the Program for the Annual Meeting. Student Research Award competitors were not indicated in the Program. However, competitors have been identified to Section chairmen and vice-chairmen; their names will be announced at a particular Section's paper session(s) during the Annual Meeting. The following tabulation reflects the entries by Section of the Academy.

<u>Section</u>	<u>Paper</u>	<u>Poster</u>
I. Biological Sciences	13	4
II. Chemistry	2	0
III. Geology	0	0

Minutes

IV. Forestry, Geog., etc.	6	0
V. Physics & Math	0	0
VI. Industry & Econom.	0	0
VII. Science Educ.	1	0
VIII. Behav. & Soc. Sci.	1	0
IX. Health Sciences	1	0
X. Eng. & Comp. Sci.	10	0
XI. Anthropology	1	0
TOTAL	35	4

Student Travel Grant: Twenty-eight students, each of whom will be presenting either a paper or poster at the Annual Meeting, applied for a Student Travel Grant. The budget allocation for this expense is \$600. The budget allocation for the Student Research Award Competition is \$550. This year, we will be making no more than 9 awards in the Student Research Award Competition, at \$50.00 each, for a total expenditure of \$450. The \$100 "surplus" from the Competition category of the budget was used to increase the amount of money available to support student travel to the Annual Meeting, as reflected in the following table:

<u>#Students</u>	<u>Travel From</u>	<u>Travel Distance</u>	<u>Individual Award (\$)</u>	<u>Total Award (\$)</u>
1	Huntsville	0	16	16
7	Florence	150	20	140
1	Jacksonville	200	25	25
15	Birmingham	200	25	375
3	Tuskegee	400	35	105
1	Auburn	400	35	35
TOTAL	28			696

Student Research Grant: Ten applications for a Student Research Grant have been received by the Committee. The following table indicates distribution of the applications by Section of the Academy, University/College affiliation, and Undergraduate/Graduate status. The Committee will meet Thursday, March 25, 1993 to determine grant recipients. Grant recipients will be announced at the Annual Business Meeting, Friday, March 27.

<u>Section</u>	<u>Applications</u>	<u>Affiliation</u>	<u>*Status</u>
I. Biological Science	4	UAB	U
	1	UAB	PB
	2	UAB	G
IX. Health Sciences	1	UAB	U
X. Engin. & Comp. Sci.	2	UAB	G
Total	10		

*Status: U = Undergraduate
 PB= Post-Baccalaureate
 G = Graduate

Minutes

Student Research Award (Paper)

Powell, Mickie	\$25.00	I.	Biology (UAB)
Chava, Kiran	\$25.00	I.	Biology (UAB)
Ma, Kequin (Tuskegee)	\$50.00	II.	Chemistry
Hall, Claudette	\$50.00	IV.	Forestry, Geog., Conserv. & Planning
(AL A&M)			
Stover, Lynn	\$50.00	VII.	Science Educ. (UA Sch. of Nursing)
Ahrens, Pamela	\$50.00	VIII.	Behav. & Soc. Sciences (UNA)
Kim, Hiryoung	\$25.00	X.	Engineering & Comp. Scien. (UAB)
Muthukrishnan, Prakash	\$25.00	X.	Engineering & Comp. Scien. (UAB)
Warner, Cassandra	\$50.00	IX.	Health Scien. (UAB)

Student Research Award (Poster)

Lee, Chi-Ying	\$50.00	I.	Biology (UAB)
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Student Research Grant

Bryan, Patrick	\$250.00	I.	Biology (UAB)
Chava, Kiran	\$150.00	I.	Biology (UAB)
Graves, Sharon	\$150.00	I.	Biology (UAB)
Kim, Hiryoung	\$125.00	X.	Engineering & Comp. Scien. (UAB)
Krishnamraju, Prakash	\$225.00	X.	Engineering & Comp. Scien. (UAB)
Law, Robert	\$150.00	I.	Biology (UAB)
Meade, Mark	\$250.00	I.	Biology (UAB)
Perry, Andra	\$150.00	I.	Biology (UAB)
Ng, Wee-Yao	\$150.00	I.	Biology (UAB)

5. Long Range Planning - Dr. Adrienne Ludwick presented the following:

The October 1992 minutes give a summary of the work of this committee during the past years. Any of the items discussed in the October report are worthy of consideration. However, in the interest of possible action, the committee recommends the following:

The President and/or the Executive Committee charge the Long Range Planning Committee to develop a report on the feasibility and utility of establishing a permanent office of the Academy with a full-time Executive Director.

The report should be due at the Spring 1994 meeting of the Academy.

Minutes

6. Auditing - Sr. Academy - The following report was prepared by Drs. Gary Poirier and Wayne Lacy:

This is a report of the AAS Auditing Committee for the period from 10/92 to 3/93. We have examined the books provided by AAS Treasurer, Dr. Larry K. Krannich. We have satisfied ourselves that the receipts and expenditures, as presented to us, are correct and that all expenditures are legitimate expenses.

The net worth as of 3/13/93 is \$58,142.52.

7. Auditing - Jr. Academy - Dr. Viohl and Ms. Barbara Reynolds submitted this report:

This is a report of the Alabama Junior Academy of Science Auditing Committee for the July 1991 - July 1992 financial year. We have examined the books provided by the Alabama Junior Academy of Science Treasurer, Dr. Eugene Omasta. We have satisfied ourselves and the receipts and expenditures, as presented to us are correct and that all expenditures are legitimate expenses.

The net worth as of 6/30/92 is \$3,519.10.

8. Editorial Board and Associate Journal Editors - the following was reported:

Currently, the Academy has the following 14 institutions who are listed as Benefactors of the Journal:

Auburn University
Birmingham-Southern College
University of Montevallo
Auburn University at Montgomery
University of South Alabama
Troy State University
University of Alabama at Birmingham
Jacksonville State University
Tennessee Valley Authority
University of Alabama
Tuskegee University
Mobile College
University of North Alabama
Samford University

Total support for the Journal for this past year was \$4,050.00. I am working with other institutions, encouraging them to become Benefactors.

9. Place and Date of Meeting - Dr. David Nelson submitted the following:

The following meeting sites have been previously approved by the Executive Committee of the AAS:

1994 - Troy State University
1995 - U.A. Birmingham
1996 - Tuskegee University

Minutes

If the Executive Committee wishes to plan for 1997, the Committee on Place and Date of Meeting recommends that we approach either Samford University or Auburn University at Montgomery. We met at Samford in 1980 and UAM in 1986. Apparently, there has been some difficulty securing a commitment from Samford several years in advance. If we are not able to meet at Samford, we should try AUM. Thereafter, we may want to consider a northern location such as UNA.

10. Newsletter - no report.

11. Public Relations - Dr. Kent Clark submitted this report:

Three press releases have been written concerning the Academy of Science and are enclosed. Once concerns the resolution on using animals in experimentation, one on the symposium on the zebra mussel infestation, and of course one on the annual meeting. I gave these to our P.R. department here who released them to the local press. I am told that they will be then put on the state wires for other media to pick up.

These press releases have also been given to Dr. Richard Lumpkin at UAH who handled them at that end of the state. Many thanks to him for that help.

I also want to thank Dr. Wilbur DeVall and Dr. Ellen Buckner for their help.

12. Archives - Dr. Curt Peterson presented the following report:

There have been no additions to the Academy's archival holdings in the past 12 months. I continue to encourage all members of the Academy to submit records to the Archives. I will be pleased to assume responsibility for transferring the records to the Archives. Please contact me at the Department of Botany and Microbiology, Auburn University, AL 36849-5407, Telephone - (205) 844-1632, FAX - (205) 844-1645.

13. Science and Public Policy - A shortened version of Dr. John Frandson's report follows. The complete report may be obtained from the Secretary or Editor.

Since its last report to the Executive Committee, this committee has:

- 1) A letter to the State Superintendent of Schools and members of the State Board of Education.
- 2) Prepared a letter to all members of the Academy soliciting their participation in our efforts to improve the quality of science education in the public schools.
- 3) Is now preparing a letter to science educators and other selected professional people informing them of our concern over the quality of science education and soliciting their assistance in formulating strategies that may lead to its improvement.

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- 4) Prepared a letter that was sent from the president's office to all members of the state legislature advising them of the zebra mussel symposium.
- 5) Prepared forms inviting interested members to submit their names if they would like to be considered for the pool of resource persons this committee is developing.

The committee will hold its next regular meeting in late summer or early fall.

14. Gardner Award - Dr. Richard Shoemaker prepared this report:
From the single application the committee received, we recommend that no Wright A. Gardner Award be made this year.

15. Carmichael Award - Dr. Velma Richardson presented this report:
Since its last report to the Executive Committee, the members of this committee have reviewed the articles published in the Journal of the Alabama Academy of Science in 1992 (Vol. 63), selected the most outstanding article, and communicated this information to President Moeller.

The members of the Committee selected Pan-Wen Hsueh and James B. McClintock (Department of Biology, University of Alabama at Birmingham), and Thomas S. Hopkins (University of Alabama, Tuscaloosa) as the 1993 recipients of The Emmett B. Carmichael Award for their article, "Factors Affecting the Population Dynamics of the Lesser Blue Crab (*Callinectes Similis Williams*) in Barrier Island Salt Marsh Habitats of the Gulf of Mexico". This article appeared in the January 1992 issue of the Journal.

According to the By-Laws of the Academy, recipients of the Carmichael Award receive a suitably executed plaque and a \$250 prize at the Annual Joint Banquet. In this case, since there are multiple authors, the Award will carry the names of the three recipients, and there will be an equitable distribution of the monetary prize.

The quality of the papers was excellent but there were few candidates (10 articles). Therefore, we are encouraging all members of the Academy to submit at least one article to the Journal in 1993.

Faithful and hard-working members of the Carmichael Committee include: James T. Bradley, (ex-officio), Department of Zoology and Wildlife, Auburn U; Ed Joubert, Department of

Minutes

Psychology, U of North Alabama; Wayne Shew, Division of Science and Math., Birmingham-Southern; and Thomas Webb, Department of Chemistry, Auburn U.

16. Resolutions - no report.

17. Nominating Committee - submitted by Dr. Omasta:

The nominating committee recommends the following slate of candidates for the indicated positions:

<u>Position</u>	<u>Candidate</u>
First Vice-Pres.(President-Elect)	Gene Omasta
Second Vice-President	Dan C. Holliman
Counselor to the Junior Academy	B.J. Bateman
Assoc. Counselor to Jr. Academy	Sandra Caudle
Coord. of State Science Fairs	Mary Thomaskutty
Trustee	Samuel B. Barker
Trustee	Stanley T. Jones
Trustee	Joseph C. Thomas
Trustee	James C. Wilkes

In addition, the following Chairs and Vice-Chairs were elected in section business meetings:

Section Chair of Biol. Sciences	Stephen Watts
Section Vice-Chair of Biol. Sci.	David Nelson
Section Chair of Indust.& Econ.	Rick Lester
Section Vice-Chair of Ind. & Econ.	Janes G. Alexander
Section Vice-Chair of Sci. Education	Tom Bilbo

18. Mason Scholarship - the following was submitted by Dr. Stan Jones:

1) There were only 3 applications for the teacher education scholarship this year, down from 4 last year. The low number of applicants is a continuing concern, which the committee will work on in the coming year. Of the 3 candidates, 1 was outstanding, and an offer to him will be going out soon.

2) A proposed amendment to the bylaws formalizing the Mason Scholarship Committee will be presented for the Executive Committee's consideration under old business.

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3) As determined by the Executive Committee last fall, the "mini-grant" award, which is normally budgeted at \$1,000 for workshops in science education, will not be offered this year.

Old Business

The following proposed amendment to the By-Laws was presented and approved:

Add to Article IV, Section 1, Standing committees of the Academy:

s) William H. Mason Scholarship Committee: This committee shall consist of three (3) members serving for two (2) years each. At least one of the committee members shall be from the Science Education Section of the Academy. The committee shall formulate selection criteria and solicit applications for the William H. Mason Science Teacher Scholarship. This scholarship is awarded to college graduates with backgrounds in the sciences who are returning to college to prepare for a career in teaching. Recipients are required to teach for at least one year in an elementary or secondary school in the State of Alabama after earning teacher certification with the assistance of this scholarship. The committee shall select the best candidate(s) and forward their decision to the President of the Academy and to the Executive Director, who shall inform the successful candidate(s). The amount of the awards shall be determined by the Executive Committee of the Academy.

New Business

There being none, the meeting was adjourned.

ddendum to the minutes: The following is a list of the Gorgas Scholarship Winners selected during the AAS Annual Meeting:

he winner of the first-place tuition grant of \$2500 was:

(S) Parvati Devi Daram, 123 River Haven Circle, Hoover, AL 35244.
Resource Learning Center. Dr. Trudy Anderson, Teacher.

rst alternative and winner of a \$1500 tuition grant was:

(S) Bradford Daniel Ricketson, 1165 Alford Avenue, Birmingham, AL 35226.
Resource Learning Center. Howard Jones, Teacher.

cond alternative and winner of a \$1000 tuition grant was:

(S) Brian Craig Heaton, 1117 Belleville Avenue, Brewton, AL 36426.
Alabama School of Mathematics and Science. Sharon Peacock (T.R. Miller
High School), Teacher.

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Third alternative was:

(S) Jennifer Leigh Hedrick, 8713 Highway 79, Pinson, AL 35126-2549. Shades Valley Resource Center. Howard Jones, Teacher.

Fourth alternative was:

Jeffrey Shane Peeden, Route 7, Box 58, Florence, AL 35630. Henry A. Bradshaw High School. Cynthia Tillery, Teacher.

Fifth alternative was:

Matthew Van Hester, Route 6, Box 229, Russellville, AL 35653. Russellville High School. Dr. Maureen Kendrick Murphy, Teacher.

Sixth alternative was:

Raynon A. Andrews, 3415 Darlene Circle, Huntsville, AL 35810. Oakwood Academy. Joyce So'Brien, Teacher.

Unable to exhibit:

(S) Michael Rummire Tehranchi, 3212 Altaloma Drive, Vestavia Hills, AL 35216. Vestavia Hills High School. Kay Tipton, Teacher.

Peily Soong, 2355 Tyrol Place, Vestavia Hills High School. Kay Tipton, Teacher.

Carla A. Cargill, 2205 Apache Drive, Huntsville, AL 35810. Huntsville High School. Meryal Smith, Teacher.

The rankings were established by a panel of judges consisting of department heads, deans, and professors from many of the leading universities and industries in Alabama.

Winners and finalists in the Gorgas Contests receive offers of tuition scholarships to colleges and universities in Alabama for the study of science. The Gorgas Foundation is named for General William Crawford Gorgas, the Alabama physician who conquered yellow fever in the Panama Canal Zone and later became the Surgeon General of the U.S. Army. The purposes of the Foundation are to promote interest in science and to aid in the education of promising students.

(S) Semifinalist 52nd Westinghouse Talent Science Search.

Notes

Notes

INSTRUCTIONS TO AUTHORS

Editorial Policy: Publication of the *Journal of the Alabama Academy of Science* is restricted to members. Membership application forms can be obtained from Dr. Larry R. Boots, Department of Obstetrics & Gynecology, University of Alabama, Birmingham, AL 35294. Subject matter should address original research in one of the discipline sections of the Academy: Biological Sciences; Chemistry; Geology; Forestry, Geography, Conservation, and Planning; Physics and Mathematics; Industry and Economics; Science Education; Social Sciences; Health Sciences; Engineering and Computer Science; and Anthropology. Timely review articles of exceptional quality and general readership interest will also be considered. Invited articles dealing with Science Activities in Alabama are occasionally published. Book reviews of Alabama authors are also solicited. Submission of an article for publication in the *Journal* implies that it has not been published previously and that it is not currently being considered for publication elsewhere.

Submission: Each manuscript will receive at least two simultaneous peer reviews. Include in your letter of transmittal the names, addresses, and telephone numbers of at least four qualified referees. Do not include names of individuals from your present institution.

Manuscripts: Consult recent issues of the *Journal* for format. Double-space manuscripts throughout, allowing 1-inch margins. Number all pages. Submit the original and two copies to the Editor. Papers which are unreasonably long and verbose, such as uncut theses, will be returned. The title page should contain the author's name, affiliation, and address, including zip code. An abstract not exceeding 200 words will be published if the author so desires. Use headings and subdivisions where necessary for clarity. Common headings are: Introduction (including a literature review), Procedures (or Materials and Methods), Results, Discussion, and Literature Cited. Other formats may be more appropriate for certain subject matter areas. Headings should be in all-caps and centered on the typed page; sub-headings should be italicized (underlined) and placed at the margin. Avoid excessive use of footnotes. Do not use the number 1 for footnotes; begin with 2. Skip additional footnote numbers if one or more authors must have their present address footnoted.

Illustrations: Submit original inked drawings (graphs and diagrams) or clear black and white glossy photographs. Width must not exceed 15 cm and height must not exceed 20 cm. Illustrations not conforming to these dimensions will be returned to the author. Use lettering that will still be legible after a 30% reduction. Designate all illustrations as figures, number consecutively, and cite all figures in the text. Type figure captions on a separate sheet of paper. Send two extra sets of illustrations; xeroxed photographs are satisfactory for review purposes.

Tables: Place each table on a separate sheet. Place a table title directly above each table. Number tables consecutively. Use symbols or letters, not numerals, for table footnotes. Cite all tables in the text.

Literature Cited: Only references cited in the text should be listed under Literature Cited. Do not group references according to source (books, periodicals, newspapers, etc.). List in alphabetical order of senior author names. Cite references in the text by number or by author-date.

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VOLUME 64

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NO. 3

COVER PHOTOGRAPH: Mammoth Cave in Kentucky and Rickwood and DeSoto Caverns in Alabama formed by surface and subsurface water dissolving limestone and dolostone, rocks that are rich in carbonate minerals. The vast majority of caves in Alabama occur in limestone or dolostone and formed by this process. However, caves also occur in rocks that are devoid of carbonate minerals. The cover photograph shows the opening to one such cave that occurs in Pottsville sandstone, has a minimum volume of 600 cubic feet and consists of several "rooms" that abruptly change direction following prominent joints. An ample supply of water from a small draw and differential weathering of roof and wall rock led to the cave development. The origin of this cave is discussed in "Cave development by seepage weathering in Pottsville sandstone, Birmingham, Alabama" by Michael J. Neilson and Denny N. Bearce.

Michael J. Neilson is Chairman of the Department of Geology and Denny N. Bearce is Professor of Geology at the University of Alabama at Birmingham.

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NO. 3

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SAMFORD UNIVERSITY

EDITOR'S NOTE: The following article by David C. Kopaska-Merkel were published in the January issue of the Journal. The author's address printed in the January issue is incorrect. The correct address is printed below. I apologize for any inconveniences this has caused anyone.

Jim Bradley, Editor
*Journal of Alabama
Academy of Science*

VISUAL PORE-SYSTEM ANALYSIS¹

David C. Kopaska-Merkel
*Geological Survey of Alabama
420 Hackberry Lane
P. O. Box O
Tuscaloosa, AL 35486-9780*

ABSTRACT

Pore systems consist of coarser elements (pores) connected by finer elements (pore throats). Indirect methods of pore-system analysis measure pore throats better than pores, whereas visual methods capture the characteristics of pores better than those of pore throats. The geometry and topology of pore systems strongly affect fluid-flow characteristics, and pore systems classified by pore type differ systematically in fluid-flow characteristics. Hence, visual pore-system analysis is an important component of the study of fluid-flow through porous media.

A genetic pore-system classification that is congruent with geometrical differences among pore systems is most useful because predictivity is highest when classifications have a genetic basis and because groups differ in fluid-flow characteristics. Ternary pore plots, which are ternary diagrams whose apices are pore types, are simple tools that effectively summarize pore-system geometry.

CAVE DEVELOPMENT BY SEEPAGE WEATHERING IN POTTSVILLE SANDSTONE, BIRMINGHAM, ALABAMA¹

Michael J. Neilson and Denny N. Bearce

Department of Geology

University of Alabama at Birmingham

Birmingham, AL 35294

ABSTRACT

Localized ground surface collapse on the property of Our Lady of Angels Monastery, Irondale, Alabama, has recurred during the past two decades despite repeated soil fillings. The property lies on a dip slope near the crest of Flat Ridge, and is underlain by sandstone of the Pennsylvanian Pottsville Formation. Surface collapse developed from a small, shallow cave in sandstone overlain by approximately five feet of soil.

The cave roof is a single thick bed of hard, massive-bedded sandstone, dipping gently southeastward and overlain by soil. The cave, approximately 600 cubic feet, is developed in thin-bedded, extensively weathered, friable sandstone. Northwest- and northeast-striking vertical joints influence the elongate trends of the cave, and joint-block subsidence is evident in the cave roof. Surface runoff has been concentrated in a shallow draw extending southeastward downslope from Old Leeds Road at the crest of Flat Ridge to the point of surface collapse. The draw is probably joint-controlled, and runoff drains through open joints, scouring loosened sand grains. Differential weathering of roof and wall rock, controlled by lithology, bed thickness, and joint spacing, led to the cave development.

INTRODUCTION

Ground subsidence and collapse features, such as sinkholes, developed as the result of ground water solutioning of carbonate rocks, are well known in the Birmingham area (Stringfield *et al.*, 1974). However, similar features, often collectively called pseudokarst (Otvos, 1976), may develop in rocks such as sandstones and shales that contain carbonate cements or are susceptible to certain types of weathering. By ignoring the potential for pseudokarst, the assumption is sometimes made that subsurface investigation to check for collapse features is not needed prior to construction on sandstone and shale. We would caution this assumption, and we illustrate the point with the following example.

¹Manuscript received 29 April 1993; accepted 18 June 1993.

GEOLOGIC SETTING

Birmingham lies in the Valley and Ridge province of Alabama, a region underlain by folded and thrust-faulted Paleozoic strata comprised of shale, carbonate (limestone and dolostone), and sandstone (Butts, 1926). Differential weathering has produced a topography of linear narrow ridges underlain by tilted beds of sandstone that are separated by long valleys underlain by limestone, dolostone, and shale. Our Lady of Angels Monastery and the affiliated Eternal Word Television Network (EWTN) are located in Irondale, a small city located on the east side of Birmingham (SE 1/4, SE 1/4, S 19, T 17S, R 1W, Irondale 71/2' Quadrangle). The monastery property is on Flat Ridge, a cuesta capped by beds of sandstone of the Pennsylvanian Pottsville Formation that generally dip to the southeast (Fig. 1).

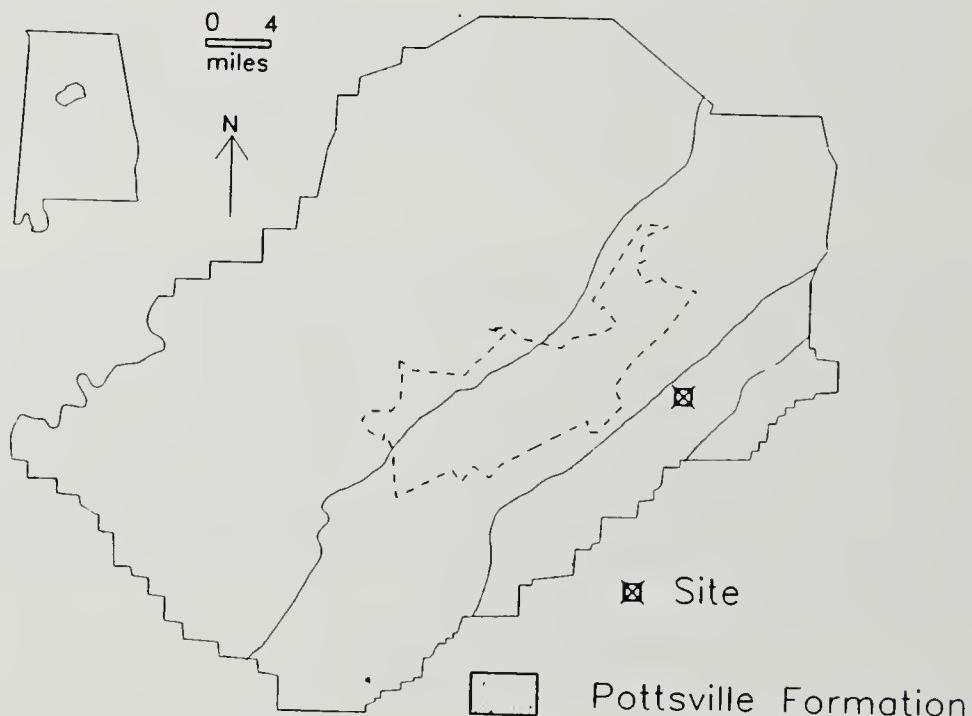


Figure 1. Location of Our Lady of the Angels and EWTN in Jefferson County. The broken lines show Birmingham city limits.

The Pottsville Formation, youngest and thickest of the Paleozoic sedimentary formations in Alabama, is the surface formation over much of the Black Warrior basin and Cahaba synclinorium (Thomas, 1991), reaching a thickness of more than 4,500 feet near Tuscaloosa (Rheams and Benson, 1982). The Pottsville Formation and the underlying Mississippian Parkwood Formation, 1,300 to 2,400 feet thick in the Cahaba synclinorium (Osborne *et al*, 1991), constitute a deltaic clastic wedge of shale, sandstone, and coal that thickens southwestward across the Valley and Ridge province and into the Warrior basin (Thomas *et al*, 1991). The basal part of the

Cave Development by Seepage Weathering

Pottsville Formation is a clean, quartzose sandstone ranging from 190 to 670 feet thick (Rheams and Benson, 1982). This basal sandstone caps Flat Ridge.

CAVE INVESTIGATION

In 1991, a local engineering firm contacted us about subsidence on the monastery property. A hole that had first opened in the 1970's and had been filled in with soil at least twice, had reopened to a depth of six feet and was 1.5 x 3 feet in plan view. The monastery officials were concerned about potential damage to an adjoining building. No damage to the building had been observed, although both a dog and a sheep are reported to have been trapped in the hole during previous times of opening.

The EWTN studio building lies on the dip slope of the cuesta, approximately 300 feet southeast of the crest of the ridge. The cave developed adjacent to a loading dock on the southwestern corner of the building (Fig. 2). The vegetation upslope from the collapse consists of a grove of pine trees with a poorly-developed grass cover. A shallow draw several feet wide and over 300 feet long leads directly to the cave site (Fig. 2).

Sufficient runoff follows this draw to inhibit grass growth. Soils on the site belong to map unit 21, described as "Gorgas-Rock outcrop-Urban land complex, 8 to 15 percent slopes" by the Soil Conservation Service (Spivey, 1982). These soils are generally thin (less than 16 inches) sandy loams that typically contain less than 25% clays. They are moderately permeable (2-6 inches/hour), acidic (pH = 4.5-5.5), have a low shrink-swell potential, and contain less than 2% organic matter. Gorgas soils belong to hydrologic group D (soils with a low infiltration rate when thoroughly wet) and, thus, have a high potential for surface runoff. According to the Soil Conservation Service, water moves in these soils predominantly downslope along the soil-rock interface or within cracks in the underlying bedrock. Water tables tend to be below the soil-rock interface.

Strata on the property are broadly warped and dip gently southeast and southwest (Fig. 2). Where exposed in a rock garden, some 300 feet northeast of the cave site, individual beds of sandstone strike N50°W and dip to the SW at 11°. Beds vary in thickness from 0.5 inches to 5 inches. Each bed has a limonite-rich crust up to 0.2 inches thick.

Vertical to sub-vertical joints cut the strata. Figure 3 shows a rose diagram of 35 joints measured in the rock garden and lists the orientation, height and width of the distinct joint sets present (following the method of Wise and McCrory, 1982). The two clearly-defined joint sets show orientations of N29°W and N2°W (A and B in Figure 2) and joint spacing of 10 and 8 inches, respectively. The two not so well defined sets (C and D) have orientations of N29°E and N39°E. Other joints appear to be random.

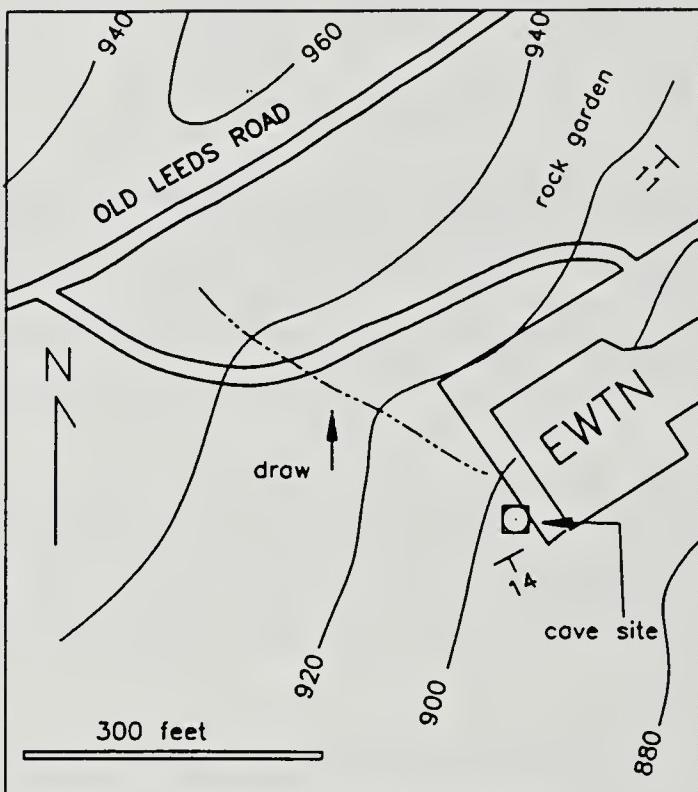
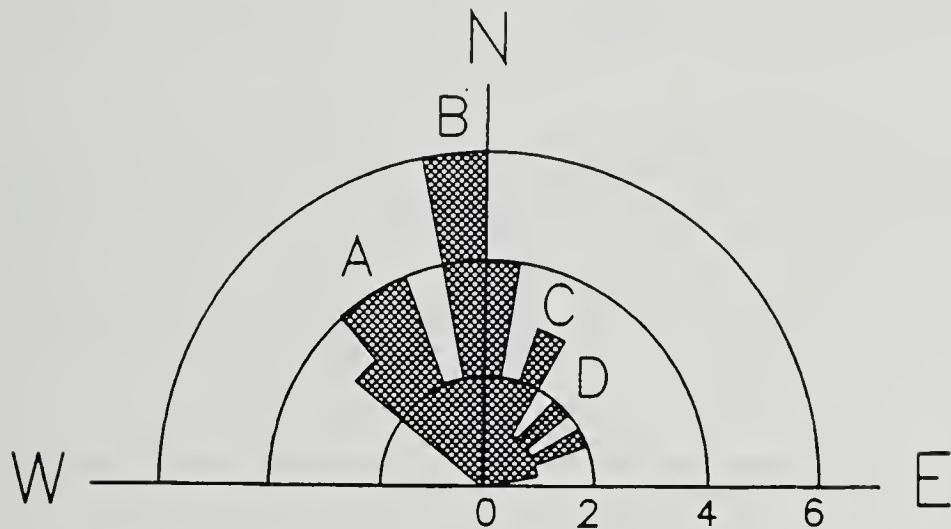


Figure 2. Topographic map of part of Our Lady of the Angels property showing the cave site and orientation of sandstone beds. Contour interval = 20 feet.

Evidence of water scour along the joints is seen in the exposed sandstones of the rock garden. A rectangular "drainage" pattern has developed on both the limonite crust and the underlying sandstones. The orientations of the larger straight channels in the sandstone generally parallel joint sets A and B. However, many of the smaller channels have approximately NE to E orientations, which represent random joints, rather than any of the joint sets. This "drainage" pattern developed in the subsurface through the action of throughflow. The pattern has been exposed by unroofing during the development of the property.

At the time of our visit to the property, the hole had been excavated to reveal a ledge of bed rock overlain by about 5 feet of soil and underlain by the entrance to a shallow cave. The roof of the cave is a single bed of sandstone about 3 feet thick with attitude N88°E/14°SE. The opening to the cave developed when a joint-bounded block of roof rock dropped to the floor of the cave. Joints measured at the cave opening and in the cave roof are 6 to 12 inches apart and trend northwest and northeast, with strike concentrations of N70°-75°W, N0°-25°W and N55°-65°E. Joints in the roof rock inside the cave are spaced about 18 inches apart, and several show vertical offset of as much as 2 to 4 inches.

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Set	Orientation	Height	Width
A	N29°W	2.7	17°
B	N2°W	3.6	19°
C	N29°E	1.3	18°
D	N39°E	1.2	22°

Figure 3. Rose diagram of 35 joints measured in the rock garden. Our Lady of the Angels property. Joint set orientations determined by the method of Wise and McCrory (1982).

Figure 4 is a plan of the observed part of the cave. The cave shows an overall network pattern in plan view with straight "rooms" that abruptly change direction. The pattern resembles that of the channels cut in the sandstones at the rock garden. The cave trends northeast, south-southwest and northwest, approximately parallel to joint orientations measured at the site (Fig. 4). Only one arm of the cave follows a well-defined joint set, set B (see Fig. 3). Maximum cave height is about 2 feet. This height decreases to a few inches, and the cave narrows to perhaps 8 inches over a distance of about 38 feet northeast from the cave opening. Southwestward the cave maintains sufficient height for crawling for about 25 feet from the cave opening, at which distance the cave turns abruptly to the southeast. Joint-block subsidence is evident over this distance, and the cave extent beyond this turn is unknown.

A large volume of sand (approximately 600 cubic feet) has been transported in the subsurface downslope from the cave site on the monastery property. There is no open stream valley immediately downslope from the excavated cave. We can only conclude that the cave provides the route for the sand removal for a considerable distance downslope from the excavation, and therefore the cave has an appreciable extent beyond the turn to the southeast (Fig. 4).

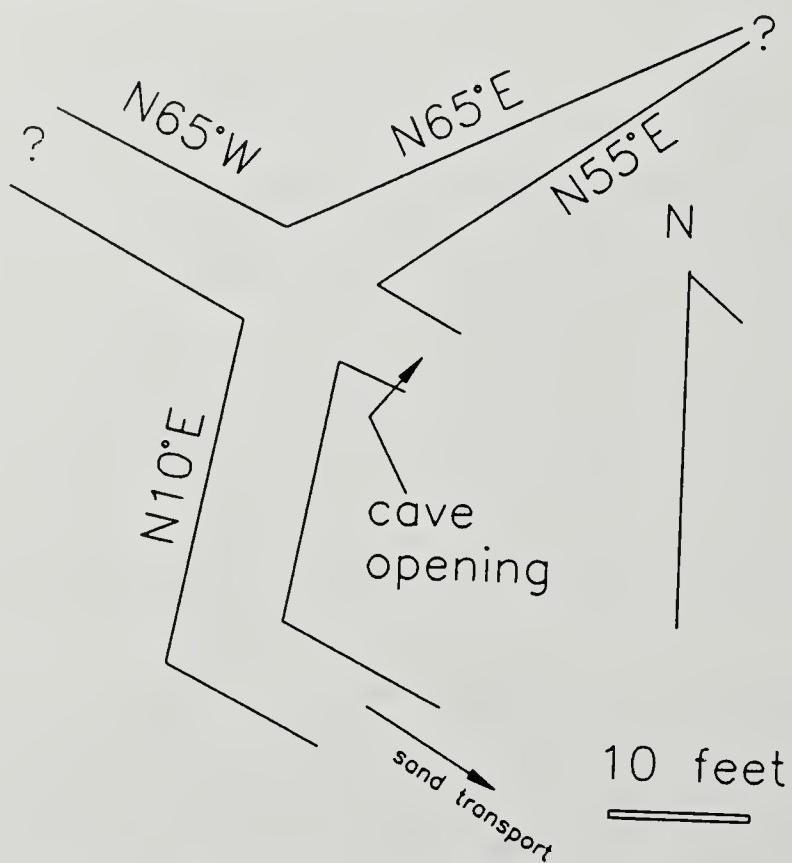


Figure 4. Sketch map of the explored part of cave.
Our Lady of the Angels site.

Cave Development by Seepage Weathering

The floor of the cave is coated with loose, wet sand several inches thick and displaying ripple marks. Evidently water flows through the cave on occasion with sufficient velocity to transport a bed load of sand. At the time of our visit water dripped steadily from several roof rock joints.

The sandstone forming the cave roof is medium-grained (grain size about 0.2 millimeters), well-sorted, massive-bedded, gray where fresh, and weathering red-brown on bedding and joint surfaces. Weathering zones around joints extend up to five inches into the rock. In contrast, the rock exposed on the northwest wall of the cave is red-brown weathering, finer-grained (grain size about 0.12 millimeters), planar-bedded sandstone. Beds are 3 -10 inches thick. The sandstone is extensively weathered, friable, and separates readily into columnar blocks parallel to bedding and to either northeast trending, closely spaced joints or spheroidal weathering shells.

In thin section, both the roof rock and wall rock of the cave consist mainly of quartz grains that show sutured contacts with very little apparent interstitial cement. Siltstone clasts composed of microscopic quartz occur sporadically. Dark-colored grains of about the same size as the other fragments and composed of sub-microscopic material are probably shale (?) mudstone) fragments. Concentrations of sub-microscopic to microscopic phyllosilicates may be weathering products of the finer-grained clastic fragments or original pore-filling material. The sutured quartz grains may be partially cemented with quartz or calcite, but neither rock is strongly indurated. Iron oxide is concentrated along grain boundaries, and rare zircon and tourmaline detrital grains are present. Although both rocks are sublitharenites under McBride's (1963) classification, the wall rock contains significantly less quartz and more shale fragments and phyllosilicate material than the roof rock (Table 1).

Table 1. Modal analyses of roof and wall rock. Points counts were carried out following the method of Neilson and Brockman (1977): 5 set of 200 points per sample were collected using a grid spacing greater than grain size. s = standard deviation.

	Roof rock		Wall rock	
	mean	s	mean	s
quartz	84.1	3.64	76.5	2.00
siltstone	2.8	1.76	2.5	2.03
shale and clay	12.8	2.42	20.5	1.97
detrital minerals	0.3	0.28	0.5	0.36

DISCUSSION

Compared to those in limestone or dolostone, caves in sandstone are relatively uncommon. For example, Daniel and Coe (1973) estimate that there are over 1,000 caves in Alabama, yet they make only passing reference to "bluff shelters" formed in

sandstone. Jones and Varnedoe (1968) indicate that only five of 123 caves in Madison County occur in sandstone (Hartselle Sandstone).

Quartz, the major component of the Pottsville sandstones, is essentially insoluble in surface and near-surface water, so to develop a cave in sandstone requires more than subsurface water solution. The sand grains must be mechanically removed. In the present case removal of a large volume of sand has apparently been accomplished by running water. The question remains; why has a cave developed at this site and in this particular thin interval of sandstone bed?

Three mechanisms will be considered for the formation of this cave: (i) collapse of a roof above a cave developed at the sandstone/carbonate boundary; (ii) subsidence above active or abandoned mine workings; and (iii) seepage weathering by subsurface water. Mechanisms (i) and (ii) require that voids develop below the sandstone and that the weight of the sandstone exceeds its strength. Jones and Varnedoe (1968) suggest mechanism (i) was responsible for several sandstone caves in Madison County, including Twin and Sublett caves. In both cases, solutioning of carbonates of the underlying Gasper Formation led to the collapse of the overlying Hartselle Sandstone. Collapse above coal mines is common in the eastern United States (Gray and Bruhn, 1984), and several collapse features in the Birmingham area have been ascribed to mechanism (ii) as the result of the collapse of underground coal and iron ore mines (Szabo *et al.*, 1979). However, neither of these mechanisms appears important in the formation of the cave in question for the following reasons. The cave occurs about 150 feet above the base of the Pottsville Formation, which is in stratigraphic contact with the Parkwood Formation, a sequence of fine sandstones and shales (Thomas *et al.*, 1991). Carbonate rocks in the Tuscumbia Formation occur about 2,700 feet stratigraphically below the Pottsville in this area. Thus, the top of the Tuscumbia Formation is about 2,900 feet below the site. Finally, neither coal nor iron ore mining has occurred under Flat Ridge.

Higgins and Coates (1990) describe seepage weathering as the effects of a "combination of processes, including both the preparatory weathering and subsequent erosion" by subsurface water, that are concentrated at sites of seepage in lithified material. They list possible processes as "intensified chemical weathering, solution and leaching . . . , granular disintegration, splitting, spalling, or flaking." We propose that seepage weathering caused the cave under examination for the following reasons.

1. Water is concentrated at the site. Normal subsurface seepage of water through the soil, along the soil-rock interface and down vertical to sub-vertical joints is augmented at the site of the cave by the shallow draw that concentrates surface runoff into a course over the cave (Fig. 2). As shown by the loose, ripple-marked sands on the cave floor, the draw provides sufficient flow to scour the loosened sand grains from the weathered joint walls and to transport them away through the enlarging cave.

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2. Suitable paths for seepage through the rocks exist. Although fresh sandstone is texturally "tight," the extensive jointing of these rock provides suitable conduits for vertical and down-dip movement of water. These are tension joints, and they may have been open from their inception, providing paths for seepage, which locally caused siltstone clast and other unstable component weathering and removal. The observed parts of the cave are sub-parallel to the directions of several of the prevalent joints (Fig. 4). Cave development along bedding may have progressed by spheroidal weathering of joint and bedding surfaces. The pattern of channels displayed in the rock garden may be an analog for the development of the cave.

3. A lithology susceptible to weathering is present. It is common for finer-grained, fluvialite sandstones to have a higher lithic fragment-silt-clay fraction than coarser-grained fluvialite sandstones, as is the case here (Table 1). The lithic fragment-silt fraction will commonly contain abundant feldspar and other easily weathered minerals. The breakdown of these components would reduce the coherence of the rock.

Are there similar caves on Flat Ridge and other sandstone-capped ridges in the Birmingham area that may eventually cause subsidence and damage? The draw is parallel to the general trend of northwest-striking joints and certainly predates all construction. Shallow draws may be surface expressions of zones of further cave development. Perhaps the shallow draws leading downslope from the crests of these ridges should be investigated more closely in future siting of buildings.

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LITERATURE CITED

- Butts, C., 1926, The Paleozoic rocks, in Adams, G. I., and others, Geology of Alabama: Geological Survey of Alabama Special Report 14, p. 40-223.
- Daniel, T. W. Jr & Coe, W. D., 1973, Exploring Alabama Caves: Geological Survey of Alabama Bulletin 102, 99 pp.
- Gray, R. E., and Bruhn, R. W., 1984, Coal mine subsidence--eastern United States in Holzer, T. L., Man-induced land subsidence: Reviews in Engineering Geology VI Geological Society of America, Boulder CO., pp 123-153.
- Higgins, C. G. and Coates, D R., 1990, Groundwater Geomorphology; The role of subsurface water in earth-surface processes and landforms: Geological Society of America Special Paper 252, 368 pp.

- Jones, W. B., and Varnedoe, W. W., Jr., 1968, Caves of Madison County, Alabama: Alabama Geological Survey Circular 52, 177 pp.
- McBride, E. F., 1963, A classification of common sandstones: Journal of Sedimentary Petrology, volume 33, pp. 664-669.
- Neilson, M. J. and Brockman, G. F., 1977, The error associated with point counting: American Mineralogist, volume 62, pp. 1238-1244.
- Osborne, W. E., Leverett, D. E., and Thomas, W. A., 1991, Depositional environments and sediment dispersal of the Parkwood Formation (Mississippian-Pennsylvanian), northwest limb of Cahaba Synclinorium, Appalachian thrust belt in Alabama, in Thomas, W. A. and Osborne, W. E., Mississippian-Pennsylvanian tectonic history of the Cahaba synclinorium: guidebook 28th annual field trip of the Alabama Geological Society, p. 53-72.
- Otvos, E. G., Jr., 1976, "Pseudokarst" and "pseudokarst terrains"; problems of terminology: Geological Society of America Bulletin volume 87, pp. 1021-1027.
- Rheams, L. J., and Benson, D. J., 1982, Depositional Setting of the Pottsville Formation in the Black Warrior basin: guidebook 19th annual field trip of the Alabama Geological Society, 94 p.
- Spivey, L. D., Jr., 1982, Soil survey of Jefferson County, Alabama: Soil Conservation Service, U. S. Department of Agriculture, Washington, D.C.
- Stringfield, V. T., LaMoreaux, P. E., and LeGrand, H. E., 1974, Karst and paleohydrology of carbonate rock terranes in semiarid and arid regions with a comparison to humid karst of Alabama: Geological Survey of Alabama, Bulletin 105, 106 p.
- Szabo, M. W., Beg, M. A., Rheams, L. T., and Clarke, O. M., Jr., 1979, Engineering geology of Jefferson County, Alabama: Geological Survey of Alabama Atlas 14, 77 p.
- Thomas, W. A., 1991, Tectonic setting of the Cahaba synclinorium, in Thomas, W. A., and Osborne, W. E., Mississippian-Pennsylvanian tectonic history of the Cahaba synclinorium: guidebook 28th annual field trip Alabama Geological Society, p. 29-36.

Cave Development by Seepage Weathering

Thomas, W. A., Ferrill, B. A., Allen, J. L., Osborne, W. E., and Leverett, D. E., 1991, Synorogenic clastic-wedge stratigraphy and subsidence history of the Cahaba synclinorium and the Black Warrior Foreland basin in Thomas, W. A., and Osborne, W. E., Mississippian-Pennsylvanian tectonic history of the Cahaba synclinorium: guidebook 28th annual field trip Alabama Geological Society, p. 37-52.

Wise, D. U., and McCrory, T. A., 1982, A new method of fracture analysis: Azimuth versus traverse distance plots: Bulletin of the Geological Society of America, volume 93, pp. 889-897.

MANOVA MODELING OF PERSONAL HISTORY, SOCIAL
READJUSTMENT, AND PREMENSTRUAL ASSESSMENT
FOR NURSING AND NON-NURSING GROUPS¹

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ABSTRACT

Relationships between selected personal history variables, stress, and premenstrual symptomatology were modeled to assess contribution of 14 antecedent characteristics to the 18 Premenstrual Assessment Form (PAF) scales. The sample was comprised of 155 individuals. Three instruments were utilized; a personal history questionnaire, the Social Readjustment Rating Scale (SRRS), and the PAF. The post hoc analysis for the six significant personal history variables and the SRRS in relation to the 18 scales of the PAF yielded associations ($p \leq 0.05$) for 17 scales of the PAF. Implications for future research include causal statistical models, such as LISREL, for better assignment of variance to sources, and determination of PMS severity levels according to life positions and areas of employment.

Premenstrual symptoms are generally experienced by most adult women of reproductive age, yet research has been undeterminant as to cause of absolute related factors. Frank (1931) alluded to a condition first described as Premenstrual Tension (PMT) and defined it as "indescribable tension and a desire to find relief by foolish and ill considered acts" (Rose & Abplanalp, 1983, p. 129). PMT may have been the initial beginning for a syndrome now recognized as Premenstrual Syndrome (PMS) (Roden, 1992). Dalton (1984) succinctly defined PMS as "the recurrence of symptoms in the premenstruum with the absence in the postmenstruum" (p. 3). Over sixty years later researchers are still embattled in determining possible relationships between presenting symptoms and Premenstrual Syndrome (PMS). A wide range of physical and psychosocial symptoms have been reported by women with stress playing a major role. Therefore, the purpose of the investigation was undertaken to identify several relationships that will contribute to a conceptual model of PMS symptomatology.

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LITERATURE REVIEW

Abraham (1986) theorized that certain factors may increase the risk of experiencing PMT and contended that childbirth, marital status, age, stress, diet, and physical activity all have a bearing on premenstrual symptomatology. Further, PMT can be more severe after multiple childbirths, especially if complicated with toxemias; married women complain more of PMT and claim it increases with divorce; PMT seems to worsen with age, especially in women in the third decade of life; and, stress worsens PMT. Abraham developed a classification and grading system for PMT labeling it the Menstrual Symptom Diary (MSD) embodying four major subgroups of symptoms and contended that stress is common to all the subgroups.

Harrison, Sharpe, and Endicott (1985) contended that PMS usually presented itself as a myriad of affective and physical manifestations. The Premenstrual Assessment Form (PAF) was used as a method for classifying the prevalence of premenstrual symptoms into 18 scales. The PAF was designed to measure changes in behavior, mood, and physical states during the premenstruum. In some women, stress was found to exacerbate PMS as demonstrated by the neuroendocrine (hormonal) feedback loop of the nervous system. In addition, the role of endocrine function may be inferred from the phenomena that post hysterectomy women (with ovaries or a portion thereof left intact) have experienced the cyclic nature of PMS, but not postmenopausal women. Rubinow (1992) determined that simple models of hormone excess or deficit do not accurately reflect causal modalities. Further postulation should include biologic, environmental, and historical triggers.

Madison Pharmacy Associates (1986) reported that PMS symptoms have begun or become more severe while taking oral contraceptives, after hysterectomy, and with age. Pregnancy complications such as miscarriage, pregnancy induced hypertension, and postpartum depression have also characterized PMS sufferers. Moreover, Watts, Butt, Edwards, and Holder (1985) studied hormonal changes in women with PMT and reported that women with PMT tended to ovulate prematurely and had smaller follicular growth than the control group when assessed by ultrasound. In addition, clinical details revealed that the mean age at menarche for PMT patients was 12.9 years and for control subjects was 12.5 years; the majority were married and had children, yet the PMT patients had a higher incidence of miscarriage than the control group. Dalton (1984) has concluded that a deficiency of the hormone progesterone is the culprit inducing PMS symptoms and should be used as a possible treatment measure. PMS symptoms were reported to increase with age. However, Freeman, Rickels, Sondheimer, and Polansky (1990) did not find significant improvement of PMS when treating patients with progesterone versus placebo for any variable of measure. In addition, a double blind study conducted by Dhar and Murphy (1990) found that mental and physical symptoms of PMS were not found to be improved through the use of Premarin during the luteal phase.

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Rose et al. (1983) suggested that the best evaluation for the symptomatology theory of PMS is through subjective accounts of patients. Clusters of symptoms constituting the syndrome were identified, suggesting PMS was not a single syndrome, but a manifestation of different disorders markedly affected by levels of stress. Further, many patients experience stressful life changes, such as divorce or relocation before seeking help for PMS. A study by Rattray (1986) evaluated the relationship between scores on the PAF and the Marital Satisfaction Inventory (MSI). This study found that if husbands believed their wives had PMS, this belief significantly correlated with their wives' PAF ratings. It was also determined PMS could have a destructive effect on the marriage and family. Winter, Ashton, and Moore (1991) reported that PMS subjects experienced significantly more dissatisfaction with marital and sexual relationships.

Boyle, Berkowitz, and Kelsey (1987) examined the prevalence of PMS in relation to selected variables and reported associations of race and increased history of abortions with PMS. White women tended to have higher reported rates of premenstrual mood changes than black women. Stout, Grady, Steege, Blazer, George, and Melville (1986) supported the findings of the study mentioned above, however, no differences were found between white and black groups except for a higher prevalence of food cravings among blacks. Further study was proposed to determine why a racial difference was found in women seeking help for PMS.

Moos (1968) used 47 symptoms on a six point scale for women to rate their experiences during the menstrual, premenstrual, and intermenstrual phases. After these responses were factor analyzed, eight factors emerged constituting cluster of symptoms that were labeled "pain, concentration, behavioral change, autonomic reactions, water retention, negative affect, arousal, and control" (p. 853). The scores on the eight clusters were slightly related to age and parity. The necessity for a standard set of symptomatology for PMS was stressed.

Wilcoxin, Schrader, and Sheriff (1976) reported that premenstrual symptoms were more prevalent during periods of stress among female undergraduate students. These individuals tended to report more instances of water gain, dysmenorrhea, and changes in behavior. The Personal Stress Inventory (PSI) was used to judge stressful events for participants. These stressful events were divided into six categories including, "personal, family, friends, academic activities, job, and extracurricular activities" (p. 404). The PSI inventory was used to produce data for analysis yielding the result that "experience of stressful events accounted for more of the variance than did the cycle phase for negative mood, but not for pain and water retention" (p. 415). Through the biopsychosocial approach in managing PMS, a decrease in levels of stress through stress reduction methods were advocated (Pitts, 1987/88; Coyne, Woods, & Mitchell, 1985; Neimeyer & Kosch, 1988; PMS Access, 1990).

The effect of major life events and daily stressors on perimenstrual symptoms (PS) were found to be more significant on the development of PS than major life

events (Woods, Most, & Longenecker, 1985). Woods (1985) also studied the relationship of socialization and stressful events on PS and determined that negative affect was the most influential cause of perimenstrual disability. A study by Lewis (1987) also supported the theory that stress correlated with PMS symptoms. In this study, the PAF proved to be a reliable tool for indicating a PMS symptom pattern. Ensign, Rowe, and Kowalski (1988) suggested operating room (OR) nurses may find that PMS compromises work performance. Moreover, the nurses missed work more often during the premenstrual phase of their cycles. This may be related to the premise that the OR is considered a high stress work environment, and stress is perceived to exacerbate PMS (Bisson & Whissell, 1989). A relationship between allergies and PMS may exist in connection with a depressed immune system, which has been correlated with persons experiencing chronic stress (Truss, 1985). Additionally, implications for candida albicans overgrowth in stressful conditions were presented with the possibility of improvement through antifungal therapy.

Holmes (1978) indicated that life changes, emotions, and psychosocial factors influenced disease processes. He contended that a relationship existed between recent life changes and the possibility of illness. Holmes and Rahe (1967) developed the Social Readjustment Rating Scale (SRRS) that measured 43 life events based on the amount of life stress produced by each. The amount of stress and its influence on the severity of life changes was related to the likelihood of an illness developing. The SRRS was used in a study by Slaninka (1989) to calculate stress values of female graduate nursing students within the last 12 months of graduate study. Results revealed 28% of the students experiencing high levels of stress with manifesting demographic characteristics that included: marital status, children, employment status, age, and area of study. The SRRS was also used by Peters (1989) to determine stress levels of women that were diagnosed by gynecologists as having PMS. Results indicated that stress levels influenced the premenstrual symptom severity levels.

The purpose was to model the relationships between selected personal history variables, stress, and premenstrual symptomatology while determining the contributions of 14 antecedent characteristics to the 18 PAF scales. Clearly more data are needed for promoting understanding of the PMS phenomenon in women who suffer its debilitating effects. The literature points to stress and its consequences as antecedent to the onset of PMS in many women, especially to severe PMS symptomatology. These data need to be analyzed in designs yielding understanding for other relationships suggested in the literature to determine relative associations with PMS of variables that may jointly influence the symptomatology.

Based on the purpose of the study and the literature review, the following research questions were formulated:

1. Are there differential effects attributable to selected personal history variables on PAF scores?

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2. Is there a relationship between the SRRS and the PAF?
3. Are there efficacious interaction effects among pairs of personal history variables used as sources in statistical models?

METHOD

Sample

The population selected for the study included (a) nursing personnel ($n=38$) and other women ($n=76$) who attended five PMS seminars, and (b) senior BSN nursing student volunteers ($n=41$). This sample was purposely chosen by the researcher, as a population of PMS sufferers was essential to the modeling concept of occupation having a relationship with PMS symptomatology. It was assumed that individuals attending PMS seminars had experienced episodes of symptoms and were interested in controlling these symptoms. The title of the seminars was "PMS: How To Live With It." The nursing students were selected as the PAF was normed on both nursing students and the general population. The sample size was 155. Although 185 individuals were eligible, 30 chose not to participate, yielding a participation rate of 83.8%.

Instrumentation

Three instruments were used to collect data. Approximately 45 minutes were required to complete the questionnaires. All instruments were administered prior to the seminar to control for biasing effects.

Personal History Questionnaire. The personal history questionnaire consisted of 14 items. The items included: age, race, menstrual age, marital status, years of college, occupation, pregnancies, living children, oral contraceptive use, hysterectomy, hormone replacement, vaginal yeast infections, reported having PMS, and SRRS. The composition of this questionnaire was determined by literature review and content validity was examined by a three member panel of nursing experts.

Premenstrual Assessment Form (PAF). A 95 item Premenstrual Assessment Form (PAF) developed by Halbreich, Endicott, Schacht, and Nee (1982) was used to assess premenstrual symptoms. The PAF included items in three general categories: (a) timing of the symptoms, (b) changes associated with the period before menses, and (c) severity of the changes. During the selection of the item pool for the development of the PAF, the developers initially began with a pool of 200 items. These 200 items were reduced to 150 items by combining similar items for initial testing on selected subjects. Statistical analyses of the 150 items led to final selection of the 95 item PAF, which was subdivided into 18 scales incorporating physical and psychosocial categories. These 18 scales were configurated by the intercorrelations between items and related alpha coefficients.

As a point further validating its use with participants in the current study, the PAF was initially tested on two groups of women; female employees at a research institute, and student nurses. The instrument was suitable for this study since it was normed on a nursing population. A shorter version of the PAF has been designed, but was not chosen as greater detail was desired (Allen, McBride, & Pirie, 1991). The PAF employed a Likert scale of 1-6 for severity of changes, which were reported as means for each scale. Reliabilities for the 18 scales of the PAF were reported by its authors in the range of .61 to .91 (Halbreich, et al., 1982). Cronbach's alpha for this study for the 18 scales ranged from .64 to .96.

Social Readjustment Rating Scale (SRRS). The SRRS was developed by Holmes et al. (1967) and consisted of 43 life events graded by the degree of stress each event produced. This scale was initially introduced by a clinical psychologist who also participated in the first PMS seminar. The psychologist was asked to present relaxation techniques, as stress management was a subject of seminar presentation. The SRRS was chosen for subsequent seminars based on the clinical psychologist's recommendation. The SRRS items were empirically derived from observed clinical experiences through retrospective and prospective studies that focused on the change in health after a stressful life experience. Numerical values were assigned to each item of the SRRS as statistically determined by the norming group. Scores were totaled for the participants using points indicated on the scale. Reliability coefficients ranged from .78 to .83 as reported by its authors. For this study, the computed raw data alpha was .62, the standardized data alpha was .64. This scale was chosen to determine the degree of association between measures of stress and assessments of premenstrual symptomatology.

Procedure

Before the beginning of the seminars the purpose of the study and consent forms were signed. After consent was obtained, all instruments were distributed and completed prior to the seminar presentation. The sample was obtained from area hospitals and two area universities. The universities were non-health care centers. The BSN nursing students were recruited from a different area university than the one in which the seminars were presented, and were not seminar participants. The purpose of the study was explained to the participants/students by the researcher and methods of maintaining confidentiality were confirmed in accordance with human subject protection. Participation was voluntary and anonymity was protected by using a numbering schema. Subjects answered questions directly on the questionnaires and answers were coded into a data set for computerized statistical analyses.

Data were analyzed by the following procedures: frequencies and percentage distributions for values of the personal history variables, interactions between selected personal history variables, and MANOVA. To examine variables relating to PMS symptomatology, statistical modeling evolved through stages including an initial theoretical model and adjustments produced by eliminations of non-significant

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sources. Preliminary MANOVA modeling permitted development of an essentially noise-free model by including only sources having significant Wilks' Lambda values with the 18 scales of the PAF. The variable sequencing in the model regarding age, race, menstrual age, marital status, and the SRRS appeared before the variable occupation had been determined by the literature review. Other variables were added to increase the sensitivity of the model by adding other known sources of PMS symptoms, thereby reducing residual error. It was not possible to get an exact order for complete sequential analysis. Order was done in three stages. The first stage controlled before introduction to occupation; the second stage that enhanced sensitivity of the model by reducing the residual mean squares; thus, decreasing the mean square residual, increasing F and finding occupation as a significant source; and, the third stage yielded the final model.

RESULTS

Demographic Data

Selected personal history variables are shown in Table 1. The majority (65.2%) of the subjects were between the ages of 24-41, the greatest of which were white. Age of menstrual onset for the majority (84%) ranged between 12 and 15. Married subjects comprised 59.4% of the sample population with 60.7% of them having from 2-4 years of college education. The majority (64.5%) listed their occupation as either professional or students. Of the 53 subjects listed in the occupation category (student), 41 were identified as BSN nursing students. Pregnancy was reported by 61.3% of the participants with 58.7% having living children. The majority had taken oral contraceptives, but had not had a hysterectomy, received hormonal replacements, or experienced chronic vaginal yeast infections. The majority (74.2%) reported that they believed they had PMS (Table 1).

Preliminary Model for MANOVA.

Initially, there were 13 potential personal history variables and the SRRS included in a model with seven interactions selected for their potential theoretical efficacies. These were tested in separate models with only the significant personal history variable and the SRRS being retained in more complicated designs. The final model included only those variables that were significant as sources of variance. Of the 13 personal history variables, the SRRS and the seven interactions depicted in Table 2; five personal history variables and the SRRS were significant at the $P \leq 0.05$ level. No interactions were significant (Table 2).

Final Manova Model

In the final model, eight variables were excluded because preliminary analyses failed to reveal sufficient variation for meaningful interpretation. The significance levels for the remaining variables ranged from 0.0258 for the source menstrual age, to 0.0001 for the source SRRS ($p \leq 0.05$). Five personal history variables and the SRRS were retained in the final model reported in Table 3.

TABLE 1

Frequency and Percentage Distribution of Selected Personal History Characteristics (N=155)

Source	N	%	Source	N	%
Age			Pregnancies		
17-23	39	25.2	0	60	38.7
24-29	24	15.5	1	28	18.1
30-35	41	26.5	2	37	23.9
36-41	36	23.2	3	22	14.2
42-47	10	6.4	4 or more	5	3.2
48-54	5	3.2			
Race			Living Children		
White	138	89.1	0	64	41.3
Black	16	10.3	1	31	20.0
Other	1	0.6	2	37	23.9
			3	20	13.0
			4	2	1.2
Menstrual age (onset)			5 or more	1	0.6
10	6	3.9			
11	16	10.3	Oral Contraceptives		
12	50	32.3	Yes	126	81.3
13	48	31.0	No	29	18.7
14	19	12.3			
15	13	8.4	Hysterectomy		
16	2	1.2	Yes	9	5.8
17	1	0.6	No	146	94.2
Marital Status					
Married	92	59.4	Hormonal Replacement Therapy		
Single	51	32.9	Yes	18	11.6
Divorced	12	7.7	No	137	88.4
Years in College					
0	25	16.1	Chronic Yeast Infection		
1	20	12.9	Yes	27	17.4
2	19	12.3	No	128	82.6
3	41	26.5			
4	34	21.9	Reported PMS		
5	11	7.1	Yes	115	74.2
8	5	3.2	No	40	25.8
Occupation					
Clerical	24	15.5			
Professional	47	30.3			
Student	53	34.2			
Housewife	20	12.9			
Other	11	7.1			

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TABLE 2

MANOVA Wilks' Lambda and Exact F Statistics for the 18 Scales of the Premenstrual Assessment Form (PAF) by Personal History Variables, Social Readjustment Rating Scale (SRRS), and Selected Personal History Variable Interactions (n = 155).

Source	S	M	N	Wilks Value	EXACT F				P>F
					Value	Num DF	Den Df		
Age	1	8	52	0.803	1.442	18	106	0.1275	
Race	2	7.5	52	0.716	1.070	36	212	0.3718	
M Age	1	8	52	0.766	1.789	18	106	0.0358	
Marital	2	7.5	52	0.605	1.677	36	212	0.0137	
YrsColl	1	8	52	0.804	1.430	18	106	0.1328	
Occup	3	7.5	52	0.522	1.426	54	317	0.0343	
Preg	1	8	52	0.835	1.163	18	106	0.305	
LivChld	1	8	52	0.840	1.120	18	106	0.3438	
Contra	1	8	52	0.812	1.359	18	106	0.1682	
Hyster	1	8	52	0.864	0.924	18	106	0.5517	
Hormone	1	8	52	0.690	2.639	18	106	0.001	
Yeast	1	8	52	0.825	1.241	18	106	0.2433	
PMS	1	8	52	0.742	2.046	18	106	0.0129	
SRRS	1	8	52	0.609	3.771	18	106	0.0001	
M Age* Marital	2	7.5	52	0.756	0.881	36	212	0.6658	
M Age* Preg	1	8	52	0.792	1.545	18	106	0.0891	
Preg* Marital	2	7.5	52	0.765	0.843	36	212	0.7239	
SRRS* Occup	3	7	52	0.689	0.779	54	317	0.0867	
SRRS* Hormone	1	8	52	0.766	1.797	18	106	0.0348	
SRRS* PMS	1	8	52	0.960	0.240	18	106	0.9994	
SRRS* Occup* PMS	3	7	52	0.710	0.713	54	317	0.9344	

P ≤ 0.05

TABLE 3

Final Model for MANOVA Wilks' Lambda Criteria and Exact F Statistics for the 18 Scales of the Premenstrual Assessment Form (PAF) by Five Personal History Variables and the Social Readjustment Rating Scale (SRRS) ($n = 155$).

Source	S	M	N	VALUE	F	NUM DF	DEN DF	P > F
Menstrual Age	1	8	65	0.800	1.849	18	131	0.0258
Marital Status	2	8	65	0.670	1.607	36	262	0.0196
Hormone	1	8	65	0.677	3.471	18	131	0.0001
PMS	1	8	65	0.758	2.928	18	131	0.0033
SRRS	1	8	65	0.656	3.814	18	131	0.0001

p ≤ 0.05

Relationships Between Personal History Variables, SRRS, and PAF.

Five personal history variables and the SRRS were deemed appropriate for retention in the final model and provided the findings for all subsequent interpretations. The 18 dependent variables were the PAF scales. Reporting of univariate analyses of variance of sources having MANOVA significance for menstrual age, marital status, occupation, hormone, PMS, and the SRRS is justified, since each source has MANOVA significance in the composite 18 scale MANOVA analysis. The significance level was set at $p \leq 0.05$. The ranges for the significance levels were from 0.0456 for the source of occupation and miscellaneous behavior scale (S17) of the PAF; to 0.0001 for the source SRRS on all scales of the PAF. Univariate analyses of variance for significant sources are reported by scales in Table 4.

DISCUSSION

The overall findings of this study support the relationships between the five remaining personal history variables, the SRRS, and the PAF. Differential effects were attributable to selected variables as sources of respondent differences in accounting for variation on the PAF scales. The PAF and the SRRS had the strongest relationship of all the variables. The SRRS, which measured the amounts of stress based on life events, yielded a significance level of 0.0001 with PMS symptomatology as measured by the PAF. Stress has long been touted as markedly affecting and exacerbating PMS, and these findings have been frequently reported in the literature (Harrison et al., 1985); (Wilcoxin et al., 1976); (Abraham, 1986); (Lewis, 1987); (Woods et al., 1985); (Ensign et al., 1988); (Bisson et al., 1989); (Peters, 1989); Menstrual age, or onset of menses, ranged from 12-15 years of age, which is a wider range than for the usual pubescent and may be related to underlying hormonal

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TABLE 4

Significance Levels for Univariate Analyses of Variances of Sources Having MANOVA Significance for Five Personal History Variables and the SRRS for the 18 PAF Scales.

Scales						
Source	Low Mood 1	Endogenous Depressive 2	Lability 3	Atypical Depressive 4	Hysteroid 5	Hostility 6
M Age	0.0135		0.0203	0.0005	0.0004	
Marital	0.0015		0.0062	0.0266	0.0050	0.0005
Occupat.			0.0451	0.0089		0.0012
Hormone	0.0014	0.0017	0.0234	0.0336	0.0122	
PMS	0.0001	0.0005	0.0001	0.0001	0.0001	0.0001
SRRS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Scales						
Source	Impulsivity 10	Organic Mental 11	Fluid 12	Physical Discomfort 13	Autonomic Physical 14	Fatigue 15
M Age	0.0169		0.0175			0.0289
Marital	0.0062	0.0184			0.0039	0.0070
Occupat.	0.0108					0.0096
Hormone		0.0001			0.0001	0.0120
PMS	0.0001	0.0001	0.0001	0.0005	0.0051	0.0001
SRRS	0.0001	0.0001	0.0001	0.0004	0.0001	0.0001
Scales						
Source	Impaired Social 16				Misc Behavior 17	Misc Physical 18
M Age					0.0138	
Marital						0.0098
Occupat.					0.0456	
Hormone					0.0089	0.0020
PMS					0.0001	0.0002
SRRS					0.0001	0.0001

p ≤ 0.05

problems. Watts et al. (1985) reported that women with PMT tended to ovulate earlier and were more prone to miscarriages; thus, supporting this study that showed more pregnancies than living children. Married women with PMS symptoms seek assistance for PMS after experiencing rocky marriages and subsequent divorces (Winter, Ashton, and Moore, 1991); (Rattray, 1986); (Rose et al., 1983). In Wilcoxin et al. (1976) single college women reported increasing PMS during periods of stress.

Occupation seems to exert an influence on PMS symptomatology since 64.5% of this sample were either professionals or attending college, both of which lend themselves to stressful situations as determined by the report on graduate student stress levels by Slaninka (1989). Hormone replacement therapy was used by 11.6% of the sample population and in a space for written comments on the PAF, these individuals expressed concern that oral contraceptives exacerbated their condition. Many health care providers have sought to stabilize hormone deficient women with oral contraceptives, which generally have been found to make PMS worse. This exacerbation of symptoms due to oral contraceptive use was reported by Madison Pharmacy Associates (1986). If the premise that PMS is related to low progesterone levels in controversial, then this hormone should be the examined as the treatment of choice as reported in Freeman et al., (1990). The study participants reported improvements in their general feeling of well-being after hormonal replacement therapy, which usually included some type of progesterone. This would support the theory proposed by Dalton (1984) that a deficiency of the hormone progesterone is the culprit inducing PMS symptoms. Most of the participants believed they had PMS before completing the PAF, and this belief was supported by the results of this study. PMS has been labeled as a chronic disease process and women having experienced the syndrome would be expected to score differently on any scale suggestive of non-cyclic well-being.

PMS symptomatology is an exceedingly complex phenomenon. Also, the variables with which it is related are themselves highly intermingled and statistical modeling of the phenomenon is accomplished with difficulty. More global statistical models, for example, LISREL models, may clarify some of the complexities in PMS accountability as well as unravel relationships among variables that collectively account for variance through its capability for numerically specifying interesting indirect effects. LISREL would allow better assignment of variance to sources and would permit detection of specification errors in the modeling process. In conclusion, future research should include the determination of different severity levels of PMS symptomatology as related to physical, behavioral, and emotional changes in women according to positions in life and areas of employment.

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REFERENCES

- Abraham, G. E. (1986). *Premenstrual blues*. Torrence, CA: Optimox Corporation.
- Allen, S., McBride, C., & Pirie, P. (1991). The shortened premenstrual assessment form. *Journal of Reproductive Medicine*, 36(11), 769-772.
- Bisson, C., & Whissell, C. (1989). Will premenstrual syndrome produce a Ms. Hyde?: Evidence from daily administrations of the emotions profile index. *Psychological Reports*, 65(1), 179-184.
- Boyle, C. A., Berkowitz, G. S., & Kelsey, J. L. (1987). Epidemiology of premenstrual symptoms. *American Journal of Public Health*, 77(3), 349-350.
- Coyne, C. M., Woods, N. F., & Mitchell, E. S. (1985, November/December). Premenstrual tension syndrome. *Journal of Obstetric, Gynecologic and Neonatal Nursing*, 446-453.
- Dalton, K. (1984). *The premenstrual syndrome and progesterone therapy*. (2nd ed.). Chicago: Medical Publishing.
- Dhar, V. & Murphy B. E. (1990). Double blind randomized crossover trial of luteal phase estrogens (Premarin) in the premenstrual syndrome. *Psychoneuroendocrinology*, 15(5-6), 489-493.
- Ensign, J. E., Rowe, J., & Kowalski, K. (1988). Premenstrual syndrome. *American Operating Room Journal*, 47(4), 962-971.
- Freeman, E., Rickels, K., Sondheimer, S., & Polansky, M. (1990). Ineffectiveness of progesterone suppository treatment for premenstrual syndrome. *Journal of the American Medical Association*, 264, 349-353.
- Halbreich, U., Endicott, Jr., Schacht, S., & Nee, J. (1982). The diversity of premenstrual changes as reflected in the premenstrual assessment form. *Acta Psychiatrica Scandinavica*, 65, 46-65.
- Harrison, W., Sharpe, L., & Endicott, J. (1985). Treatment of premenstrual symptoms. *General Hospital Psychiatry*, 7, 54-65.
- Holmes, T. H. (1978). Life situations, emotions, and disease. *Psychosomatics*, 19(12), 747-754.
- Holmes, T. H. & Rahe, R. H. (1967). The social readjustment rating scale. *Journal of Psychosomatic Research*, 11, 213-218.

- Lewis, L. L. (1987). Premenstrual syndrome: Endocrine and psychosocial variables in relation to symptom severity. *Dissertation Abstracts International*, 48, 2605B.
- Madison, Pharmacy Associates. (1986). *Premenstrual Syndrome: The odds are almost even*. Madison, WI: Author.
- Moos, R. H. (1968). The development of a menstrual distress questionnaire. *Psychosomatic Medicine*, 30(6), 853-867.
- Neimeyer, G. J., & Kosch, S. G. (1988 April). An overview of assessment and treatment of premenstrual syndrome. *Journal of Counseling and Development*, 66, 397-399.
- Peters, C. J. (1989). Change event stress, anxiety levels, and premenstrual tension syndrome. *Dissertation Abstracts International*, 50, 3531A.
- PMS Access. (1990, January/February). *The race to reduce stress*, 1-3. Madison, WI: Madison Pharmacy Associates.
- Pitts, C. A. (1987/88). PMS: Assessment and management. *Nursing Forum*, 23(4), 127-133.
- Rattray, M. D. (1986). Marital Satisfaction and Premenstrual Syndrome. *Dissertation Abstracts International*, 48, 274B.
- Roden, M. (1992, July). The social construction of premenstrual syndrome. *Social Science Medicine*, 35(1), 49-56.
- Rose, R. M., & Abplanalp, J. M. (1983, June). The premenstrual syndrome. *Hospital Practice*, 6, 129-141.
- Rubinow, D. (1992). The premenstrual syndrome: New views. *Journal of the American Medical Association*, 268, 1908-1912.
- Slaninka, S. C. Selected academic and nonacademic characteristics of female graduate nursing students who have completed their graduate nursing program in Pennsylvania in 1988. *Dissertation Abstracts International*, 50, 2849B.
- Stout, A. L., Grady, T. A., Steege, J. F., Blazer, D. G., George, L. K., & Melville, M. L. (1986). Premenstrual symptoms in black and white community samples. *American Journal of Psychiatry*, 143(11), 1436-1439.
- Truss, C. O. (1985). *The missing diagnosis*. Birmingham, AL: Missing-Diagnosis, Inc.

Manova Modeling of Personal History

- Watts, J. F., Butt, W. R., Edwards, R. L. & Holder, G. (1985, March). Hormonal studies in women with premenstrual tension. *British Journal of Obstetrics and Gynaecology*, 92, 247-255.
- Wilcoxin, L. A., Schrader, S. L., & Sheriff, C. W. (1976). Daily self-reports on activities, life events, moods, and somatic changes during the menstrual cycle. *Psychosomatic Medicine*, 38(6), 399-417.
- Winter, E. J., Ashton, D. J., & Moore, D. L. (1991) Dispelling myths: A study of PMS and relationship satisfaction. *Nurse Practitioner*, 16(5), 37-38,40.
- Woods, N. F., (1985, May/June). Relationship of socialization and stress to perimenstrual symptoms, disability, and menstrual attitudes. *Nursing Research*, 34, 145-149.
- Woods, N. F., Most, A., & Longenecker, G. D. (1985, September/October). Major life events, daily stressors, and perimenstrual symptoms. *Nursing Research*, 34, 263-267.

SOCIOECONOMIC CONSTRAINTS UPON
ACADEMIC MEDICAL CENTERS:
HISTORICAL AND CONTEMPORANEOUS PERSPECTIVES¹

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Abstract:

If physicians are to influence the quality, quantity, and direction of health and medical care delivery in our society, knowledge regarding the contingencies that impact upon that care must be discerned and acknowledged. A multiplicity of factors - biomedical, economic, ethnic, political, psychological, sociological - have determined the evolution of medical care and education as it is defined contemporaneously. The historical perspective conveyed in this essay provides a rationale for recommendations regarding the economic imperatives of medical care and education, particularly with respect to the relationship between indigent patient populations and academic medical centers. Physicians must educate their patients and all members of society

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regarding collective participatory and economic obligations and responsibilities in relationship to medical care, education, and research.

Diseases desperate grown
By desperate appliance are relieved,
Or not at all.

Hamlet (Act 4, Scene 3)

Our remedies oft in ourselves do lie,
Which we ascribe to heaven.

All's Well That Ends Well
(Act 1, Scene 1)

William Shakespeare (1564-1616)

Among the approximately 2000 accredited colleges and universities within the United States of America there are 127 medical schools representing a very substantial socioeconomic entity. Wilson and McLaughlin (1984) have defined an academic medical center as "an organizational complex made up of a medical school, at least one and often several teaching hospitals, and sometimes additional semiautonomous research institutes and centers." Pragmatically, an academic medical center is a complex of facilities for medical care condensed by an institutional relationship where an attending faculty provides clinical service and performs education and research. For most of this century the growth and development of the academic medical center mutually sustained and paralleled the development of the medical profession in general. However, during the preceding three decades the goal of the profession and the goals of the academic community have diverged, because diverse socioeconomic forces have influenced the academy (Gk., *academeia*, L., *academia*, "gymnasium") to a different degree than the remainder of the profession. Several factors have impacted upon the current socioeconomic status of academic medical centers: an evolving system of medical education; public financial support of medical care; a changing focus of academia; specialization by physicians; and a modification of patient referral patterns. In this essay these factors are correlated with the current situation and status of a prototypical academic medical center and administrative plans to maintain its financial solvency.

SYSTEM OF MEDICAL EDUCATION:

Medical education in America in the Nineteenth Century was primarily proprietary. That was a major distinction from Western Europe where medical education occurred in distinguished institutions such as Guy's Hospital in London, England and The Sorbonne in Paris, France. The establishment of medical schools in Philadelphia (1765), New York City (1769), and Boston (1783), for example, was

Academic Medical Centers

an attempt by physicians (Gk., *physika*, L., *physica*, Fr., *phisiqe*, "medical" or "natural sciences") educated in Western Europe to recapitulate those "great centers of learning" in this country. Nonetheless, proprietary medical education continued to prosper, and the greatest influence of mature, well-established, and well-recognized medical schools was on the development of medical science rather than direct patient care *per se* (Garrison, 1929; Bettmann, 1956; Marks and Beatty, 1973; Lyons and Petrucelli, 1978; Wangensteen and Wangensteen, 1978; Cumston, 1987).

Whereas in Western Europe medical education was based in the laboratory and taught by those who contributed to a corpus of knowledge, medical education in this country remained largely didactic, uncontrolled, unsupervised, and unoriginal until Johns Hopkins bequeathed seven million dollars solely for construction of a hospital and university in 1873. The significance of the founding of Johns Hopkins University in 1893 was the introduction by the faculty (L., *facultas*, "branch of learning or teaching") of the notion that medical education should be a field of graduate study. Faculty were recruited for their expertise rather than solely from the ranks of private practitioners. A residency system was also introduced permitting specialty education in an academic setting in which the basic and medical sciences were paramount. These factors set the stage for preeminent scholarship in a setting of an academic medical center. State licensing boards likewise increased their stringency and legislative mandates within several states eventually required formal certification of graduate physicians. Texas established the first State Board of Medical Examiners in 1873, and by 1901, 37 states required licensure to practice medicine and surgery (Starr, 1977, 1978, 1982; Association of American Medical Colleges, 1986; Raffel and Raffel, 1989).

As university educated practitioners disseminated from their parent institutions pressure increased for reform of the American medical educational system because proprietary medical schools remained active and prosperous. Consequently, medical academicians prevailed upon the American Medical Association to establish a Council on Medical Education (AMA/CME), which enlisted Abraham Flexner and the Carnegie Foundation for the Advancement of Teaching to analyze the medical profession with respect to education. The well known *A Report to the Carnegie Foundation for the Advancement of Teaching/Medical Education in the United States and Canada* (Bulletin #4) was published in 1910. Flexner personally visited 155 medical schools and evaluated and critiqued facilities, faculties, finances, and administrations. He observed that the catalogues of many schools blatantly misrepresented the capacity of the respective institutions (Flexner, 1910, 1972):

"Touted laboratories were nowhere to be found, or consisted of a few vagrant test tubes squirreled away in a cigar box; corpses reeked because of failure to use a disinfectant in the dissecting rooms; libraries had no books; alleged faculty members were busily occupied in private practice; purported admission requirements were waived for anyone who could pay the fees."

The Carnegie Foundation Report also proposed numerous changes: (1) medical schools should be modeled on Johns Hopkins University (high ranking schools, Class A); (2) middle ranking schools (Class B) should be improved; and (3) low ranking schools (Class C) should be eliminated. The AMA/CME supported the Carnegie Foundation Report since it was perceived that the country had an abundance of "poorly educated" physicians. The recommendations resulted in an ever-tightened relationship between hospitals and universities, as the university supplied basic science expertise and the hospital provided clinical experience. Concurrent with the growth of academic faculty, "clinical faculty" became desirable for their professional prestige and as an attractant for "private patients" (Starr, 1982).

The integration of the laboratory, ward, and clinic was further refined with the establishment of the Rockefeller Institute for Medical Research (later to become Rockefeller University). That institution was established in New York City in 1901 and was supported by the income of the Standard Oil Foundation, which permitted the faculty to practice, discover, and teach on a full-time basis. Several authors have suggested that the establishment of Johns Hopkins and Rockefeller Universities represented the epitome of early modern medical care, education, and research in this country (Garrison 1929; Bettmann, 1956; Marks and Beatty, 1973; Lyons and Petrucelli, 1978; Wangensteen and Wangensteen, 1978; Cumston, 1987).

COMPETITION:

Prior to 1965 the academic medical center was characterized by relative stability. Although academic medicine was described as "threadbare and genteel" (Petersdorf, 1981), in fact support for the academic medical center increased from 1% to 5% of national medical expenditures between 1956 and 1966 (Wilson and McLaughlin, 1984). During the era of growth and expansion of the academic medical center patient care was not considered the highest priority for two major reasons: (1) funding, primarily from federal sources, was dedicated to the advancement of medical knowledge, thus the rewards for medical educators and researchers were not related to patient care; and (2) support from physicians within the community was not for the development of primary care delivery programs at the medical school. Community-based physicians opposed attenuation of their private practices by tax-supported institutions. Tolerance was maintained only when the academic medical center tacitly agreed to provide tertiary care facilities and accept patients on a referral basis from private physicians. The inevitable consequence was the education of physicians incompletely equipped to practice in a non-academic environment. Many of those physicians thus remained in academia educated from the perspective of evermore sophisticated technologies and seemingly unlimited resources (Rogers and Blendon, 1978; Igelhart, 1982; Friedman, 1984; Relman, 1984; Wilson and McLaughlin, 1984; Commonwealth Fund, 1985).

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CONFLICTS WITHIN THE AMERICAN MEDICAL ESTABLISHMENT:

Although not explicitly stated the American medical establishment was implicitly directed by and towards the health and medical care of affluent Caucasian males. Since the supply of physicians was reduced subsequent to the Flexner report, rural populations, the urban inner city disenfranchised, and the lower socioeconomic echelons were medically underserved (Pearl, 1925; Starr, 1982; Friedman, 1984; Flynt, 1989; Solomon, 1990). Private physicians' incomes rose dramatically during that era averaging four to five times the median wage a level which has been maintained to date. There also occurred a dramatic change in the professional activities of the academic physician. Whereas previously the academy had co-opted and to a large extent depended upon the practicing physician for patient referrals, the Halsteadian/Oslerian model propounded that a full-time academician also be a primary care clinician as well, and an inherent conflict of a student in competition with his teacher resulted. A second conflict which arose from the elitist approach extant at the turn of this century was the limitation of enrollees into medical schools. By 1930 there were twice as many applicants as positions and that number has remained relatively constant to date. And a third conflict was the introduction of federal fiscal legislative controls. Governmental influence in the practice of medicine until the middle of this century was limited to the provision of medical care for the indigent and "tuberculosis." Public city and county hospitals were tightly restricted in terms of funds and although there were periodic protests regarding inadequacies (Starr, 1982; Flynt, 1989; Solomon, 1990), the majority of the opposition to legislative regulation was by and on behalf of private physicians who viewed governmental financed health and medical care as intrusive upon their domain. The wedge that was inserted into that perspective was the passage of Social Security medical care entitlement legislation, the Hill-Burton Act, and the Veterans' Administration Health Care System. These entities imposed governmental influence upon the quality and quantity of health and medical care of private citizens. The Social Security legislation was the embryo for Medicare and Medicaid (*vide infra*); the Hill-Burton Act involved government in hospital construction which then mandated equitable access for all patients to those funded institutions; and the Veterans' Administration Health Care System became a vast network of hospitals and clinics. Historically, the Veterans' Administration was not the object of wrath of organized medicine to the extent of other governmental entitlement programs, probably a consequence of the political influence of veterans' groups and the perceived support by the American populace for veterans' care (Flexner, 1910, 1972; Starr, 1977, 1978, 1982; Association of American Medical Colleges, 1986; Raffel and Raffel, 1989).

FINANCIAL SUPPORT OF HEALTH AND MEDICAL CARE AND EDUCATION:

To briefly reiterate, the revisions that had occurred in medical education and funding for patient care during this century subsequently fostered intense competition: competition for student positions in medical schools; competition between medical

educators and their graduates for patients; and competition for funds for primary patient care. It was the latter that proved to be a turning point for the practice of medicine and the academic medical center in this country (Starr, 1977, 1978, 1982). Attempts to enact legislation permitting federal support for medical care expenses had been proposed by virtually every Congress since the "New Deal" era. Although factional disputes in Congress delayed this legislation until 1965, Social Security Amendment PL 92-67 was eventually enacted into law. The compromises necessary for enactment were substantive, but a three-tiered program under *Title XIX of the Code of the United States of America* emerged: *Part A* provided insurance for hospitalization to eligible elderly patients or patients with specific types of chronic illnesses (Medicare); *Part B* was a subsidized insurance program for physicians' professional fees; and *Part C* became a state-administered insurance program for acute temporary medical care of indigent patients (Medicaid). Medicare allowed physicians to charge more than the limits of its reimbursement and to seek the balance from each patient, while Medicaid mandated acceptance of the reimbursement schedule as payment *in toto*.

Virtually simultaneously, the premise of the "War on Poverty" and the "Great Society," introduced by the immense influence of then President L. B. Johnson, propounded the notion that there were too few physicians to care for the newly entitled patients. In 1963 and 1966 Congress passed a Health Manpower Education Act. So great was the perceived "crisis" that the Act established "physician-extender" programs which would educate and train paraprofessional personnel to perform some of the functions of a physician, and thus at least theoretically enable each physician to serve more patients. Capitation grants stimulated the enrollment of more medical students and mandated funding for "accelerated" educational programs, and this was wholeheartedly supported by many nationally prominent medical educators (Starr, 1982).

FOCUS OF ACADEMIA:

This health manpower legislation further and substantially modified the focus of academic medicine from the accretion of medical knowledge to the education of primary medical care delivery personnel (Freeman, 1985; Caper, 1986; Ginzberg, 1986; Light, 1986; Watt, *et al.*, 1986; Johnson, 1987; Moser, 1987). All health manpower legislation until 1977 required expansion of enrollment of medical schools, unless it could be demonstrated that increases in enrollment would be deleterious to the quality of education delivered. The Office of Economic Opportunity also mandated the establishment of "neighborhood health care centers" which performed required staff physicians. These free-standing ambulatory patient care centers were ostensibly established to serve indigent and isolated patients, but became a prototype for the independent "emergicenters" proliferating in suburbia today (Freeman, 1985; Watt, *et al.*, 1986). In addition, in an attempt to redistribute physician manpower scholarship assistance available through the National Health Services Corps sought

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to place medical care personnel in underserved areas. All these initiatives forced medical schools to respond to the imperative of clinical service much as they had previously responded to the imperative for biomedical research. As the academic medical centers moved from basic science research and tertiary care into clinical research and primary care, an inevitable conflict emerged between the providers of care in the community and in the academic medical center. In order to fulfill its new clinical service-oriented missions the academic medical center began to encroach upon its constituency. In addition to each medical school competing for more patients, there were more medical schools (88 in 1966; 127 in 1989), more medical students (7,177 in 1950; 17,186 in 1980), and more full-time medical faculty (11,224 in 1960; 53,371 in 1982) (Starr, 1977, 1978, 1982).

As funds for construction became scarce, academic medical centers perceived a need to expand their influence by affiliations with community hospitals primarily to provide sources of patients for undergraduate and graduate medical education. This technique of expansion by assimilation was successful as long as the financial underpinnings of patient care remained ascendant. However, the federal legislature responded to a societal perception that government was "too big" and entered a cost-cutting mode. In addition, the federal legislature changed its philosophy regarding medical care delivery from promoting access to containing cost, and the costs of providing medical care rose dramatically. Since the enactment of Medicare, patient generated income had grown to assume a proportion of medical school expenses at least equal to that provided by research grants. In essence, the Social Security Administration provided a major share of revenues required to operate an academic medical center (Rogers and Blendon, 1978; Inglehart, 1982; Friedman, 1984; Relman, 1984).

SPECIALIZATION AND SUBSPECIALIZATION:

An additional factor in terms of the cost of medical care and competition for patient care funds was fostered by specialization and subspecialization by physicians, which resulted in increased utilization of diagnostic and therapeutic procedures and protracted tertiary care. Counterbalancing a professed desire to educate more primary care physicians, powerful academic and socioeconomic forces existed which promoted specialization (Starr, 1977, 1978, 1982): (1) rapid advances in knowledge and its application attracted physicians to ever-narrower specialties and subspecialties; (2) use of technologically intensive methods of diagnosis and therapy was more financially rewarding than methods of practice employed delivering primary care; (3) hospitals gained a market advantage by having specialty services for patient care; (4) academic prestige accrued to faculty in specialist rather than generalist activities; (5) neither teaching methods nor financial compensation developed adequately in terms of graduate medical education in ambulatory patient care settings, such that students would be attracted to them; and (6) the profusion of specialists and subspecialists outside an academic medical center further diluted its

constituency of referral, since competent experts in the private sector were unlikely to refer patients for medical care or procedures which they themselves were qualified to deliver or perform.

PATIENT REFERRAL PATTERNS:

Nevertheless, academic physicians were often viewed as a resource of "last resort" by many patients and physicians within the community. The more critically-ill patients who required extraordinary attention tended to be referred to the academic medical center. In addition, the university hospital became a referral center for those patients unable to afford their medical care. The academic medical center thus received a reputation of attending only critically-ill or critically-poor patients.

As patient care revenues surpassed research funding in providing financial support of the academic medical center, it became necessary to redesign and redirect the systems which supported the whole, since financial support for educational programs by public and private third-party payors no longer sustained the infrastructure. Medical education was not perceived to be a responsibility of the Health Care Financing Administration. That perception supported the notion that society had never *de facto* agreed to support medical education or the non-patient care activities of an academic medical center (Anderson, 1987; Easterbrook, 1987). Consequently, in order to support the services which permitted the generation of a large volume of income from patient care, the academic medical center was forced to engage cadres of physicians who were not desirous of fulfilling other academic responsibilities (Rogers and Blendon, 1978; Iglehart, 1982; Friedman, 1984; Relman, 1984; Commonwealth Fund, 1985).

CLINICAL FACULTY:

Clinical faculty engaged in large full-time practices are those who do not wish to be engaged in basic science research. The dichotomy of an academic physician primarily caring for patients had been a contentious point among private physicians who viewed that as unfair subsidized competition. Also, from the perspective of traditional academicians clinically oriented faculty do not fulfill the conventional criteria for promotion and tenure which rest largely upon published scholarship. Institutions attempted to remedy this imbalance by providing one or more additional "tracks" for advancement. Conversely, the academic medical center risked engaging in enterprises with no reasonable scholarly potential simply because those activities resulted in much needed income. This creation of "profit centers" to support the scholarly activities of academic medical centers has continued to widen the rift between community-based and academic physicians. It has also led medical school administrators to consider commercialization to keep their institutions financially solvent (Rogers and Blendon, 1978; Inglehart, 1982; Friedman, 1984; Relman, 1984; Commonwealth Fund, 1985; Ginzberg, 1986; Schroeder, *et al.*, 1989; Taksel, *et al.*, 1989; Turner, 1989).

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PRO BONO HUMANI ET PUBLICO:

Commercialization poses a dilemma, however, since the economics of medical care delivery rarely adheres to free-market principles. The concept that more physicians would reduce the cost of each individual physician's work proved fallacious. The business and financial aspects of medical care delivery operate with greater similarity to a public utility than to a free-market system (Caper, 1986). The *modus operandi* of "hospital corporations" is relevant in that regard. Since J. D. Massey, in conjunction with Dr. Thomas Frist, formed the Hospital Corporation of America in 1968, several similar corporations have been established, but the goals of a privately held corporation differ from one responsive to public need. The "for-profit" hospitals generate a return-on-investment by increased utilization of reimbursable items and aggressive marketing strategies, while simultaneously providing lower visible charges such as bed costs, and thereby increase the degree of operating leverage by reducing fixed costs (Commonwealth Fund, 1985; Freeman, 1985; Caper, 1986; Ginzberg, 1986; Light, 1986; Watt, *et al.*, 1986; Anderson, 1987; Easterbrook, 1987; Johnson, 1987; Moser, 1987; Enthoven, 1988; Taksel, *et al.*, 1989).

Even more problematic than "mixed motives" of physician ownership and "creative" accounting and marketing, was a "decomposition of voluntarism." As the market became tighter with less latitude for non-reimbursable effort and time, clinical faculty and practitioners rationed their commitments to teaching and care of the indigent (Starr, 1977):

"The rise of the corporate *ethos* in medical care is already one of the most significant consequences of the changing structure of medical care. It permeates voluntary hospitals, government agencies and academic thought as well as profit-making medical care organizations. Those who talked about "health care planning" in the 1970's now talk about "health care marketing." Everywhere one sees the growth of marketing mentality in health care. And indeed business school graduates are displacing graduates of public health schools, hospital administrators, and even doctors, in the top echelons of medical care organizations. The organizational culture of medicine used to be dominated by the ideals of voluntarism and professionalism, which softened the underlying acquisitive activity. The restraint exercised by those ideals now grows weaker. The "health care" of one era is the "profit center" of the next."

For the academic medical center that trend was even more acute as the goals of faculty practicing in an academic setting were not necessarily congruent with those of operating an economically efficient hospital (Starr, 1982; Enthoven, 1988). Prior to entitlement programs referred to *vide supra*, indigent patients were frequently referred to a "charity hospital" or were cared for *gratis* by socially responsive

physicians. When "cost-shifting" was practiced community hospitals and academic medical centers could remain financially solvent while caring for indigent patients. Currently, this assumption of a "useful burden" is being deflected onto the academic medical center in the form of an expectation that it will assume the entire burden of uncompensated medical care. A survey by the Urban Institute/American Hospital Association in 1982 revealed that teaching hospitals provided 15% of all medical care delivered, but 43% of all "uncompensated care." That phenomenon exposed the academic medical center to a disproportionate share of the financial burden of indigent patient care. Should this share shift even further toward uncompensated care and third-party payors continue a trend of reducing cost-shiftable reimbursement, the academic medical center will become evermore tenuous in its fiscal base. Even more alarming is the perception among the private sector of the medical community that this is appropriate and acceptable (Flynt, 1989; Solomon, 1990).

PROTOTYPICAL ACADEMIC MEDICAL CENTER:

Exemplary of the impact of these socioeconomic trends upon academic medical centers is the current situation and status of the Medical Center/University of South Alabama (Rodning, 1987; Rodning and Dacso, 1987; Berger, *et al.*, 1989; Rodning, 1989; Salley and Rodning, 1989). This Medical Center is one of the oldest in the country, founded in 1704 by the *Sisters of Charity* (America). Although its name and location have been altered periodically since that time (formerly the Mobile City/County/General Hospital), the continuity of its service to the community has remained intact. The *raison d'être* of the institution since its inception has been clinical service with care of the indigent patient population an acknowledged responsibility. Since the Medical Center became affiliated with the University of South Alabama, education and research have also become prominent components of its mission. The remuneration the Medical Center received for uncompensated medical care was provided by tax revenues generated from the municipality of Mobile, but that has never fully compensated for indigent patient care expenses (Anderson, 1987). The financial burdens were so onerous that the *Sisters of Charity* (America) relinquished responsibility for the facility to the municipality in 1959, and the municipality relinquished responsibility to the University of South Alabama in 1971 (Salley and Rodning, 1989).

Financial support of the missions of the Medical Center - clinical service, education, and research - is predominantly *via* self-generated revenues provided by collections for patient care (90%). Only a fraction of that revenue is provided by municipal sources (10%). The dilemma that confronts this Medical Center is that although 60% of the patient care provided is compensable, 40% of the patient population is indigent. During fiscal year 1987-1988 the Medical Center expended approximately \$46,845,000.00 for in-hospital indigent patient care, but received only \$6,182,000.00 from the municipality for that care (Table 1). The figures quoted do not include physicians' professional fees which were uncompensated. In addition, the Medical Center cares for the vast majority of indigent patients within the municipality

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TABLE I
UNIVERSITY OF SOUTH ALABAMA MEDICAL CENTER
BAD DEBT ANALYSIS
FISCAL YEARS 1983-1988

FISCAL YEARS	GROSS PATIENT REVENUE	BAD DEBT EXPENSE	BAD DEBT %	COLLECTIONS ON BAD DEBT	AD VALOREM TAX RECEIPTS	INDIGENT CARE FUNDS	NET BAD DEBT	NET BAD DEBT %
1982 - 1983	70,220,000	24,563,000	35%	3,093,000	3,760,000	2,802,000	14,908,000	21%
1983 - 1984	67,789,000	26,428,000	39%	3,343,000	3,745,000	3,928,000	15,412,000	23%
1984 - 1985	80,036,000	28,990,000	36%	3,870,000	3,775,000	2,989,000	18,356,000	23%
1985 - 1986	90,158,000	34,858,000	39%	3,882,000	4,004,000	2,313,000	24,669,000	27%
1986 - 1987	109,053,000	42,215,000	39%	3,523,000	3,977,000	1,207,000	33,508,000	31%
1987 - 1988	121,885,000	46,845,000	38%	4,013,000	4,970,000	1,212,000	36,650,000	30%

*Net Bad Debt equals Bad Debt Expense less Collections on Bad Debt, Ad Valorem Tax receipts and Indigent Care Fund receipts.

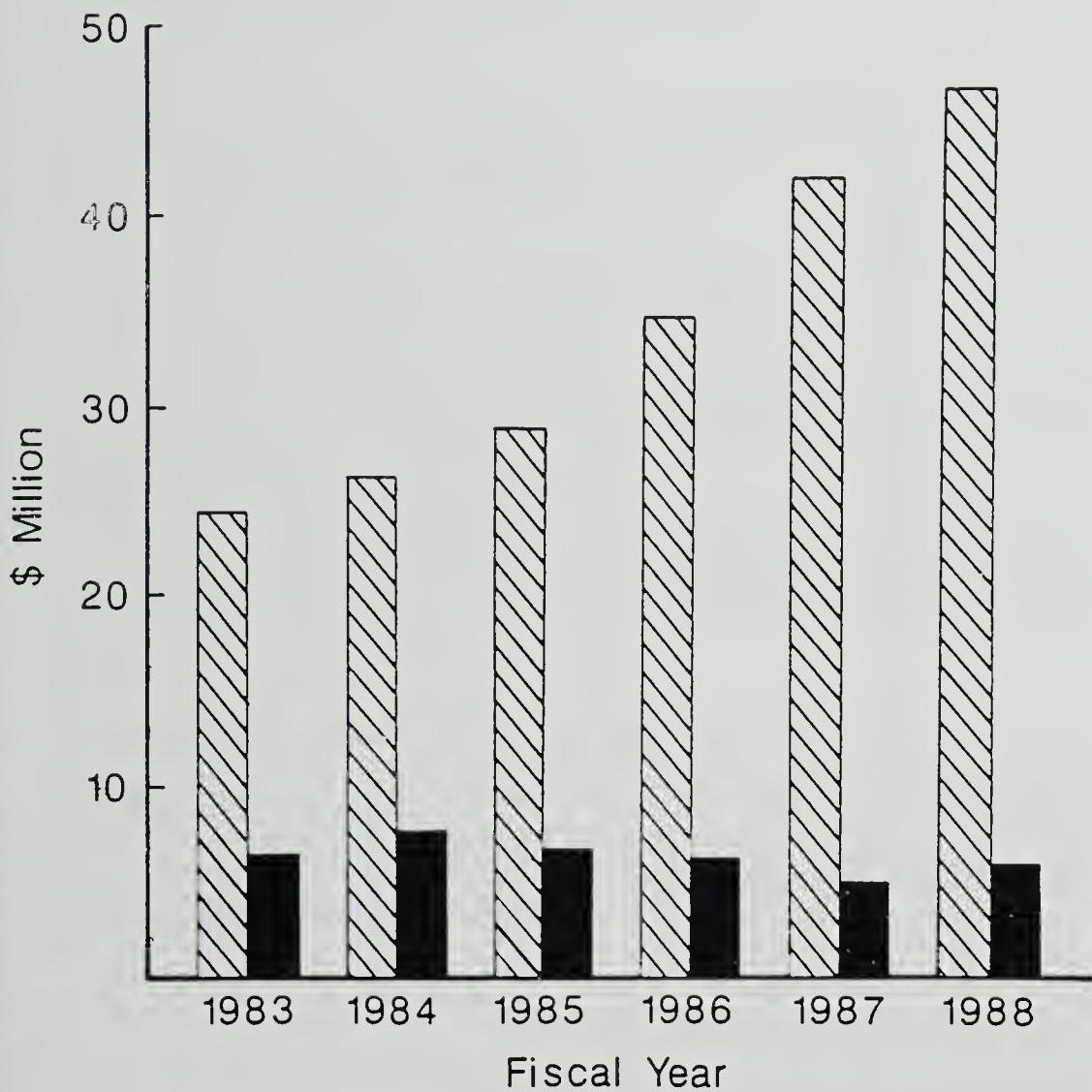
(95%), the remainder provided by other hospitals within the community - Mobile Infirmary, Providence, and Springhill Memorial. In summary, as depicted in Table 1 and Figure 1, the Medical Center noted during that decade an increased percentage and expense of indigent patient care and decreased compensation for that care provided by the municipality that it serves (Berger, *et al.*, 1989).

To cope with this disparity, the Medical Center/University of South Alabama has contemplated several mechanisms:

- denial of unfunded and non-emergent patient transfers from other hospitals;
- close scrutiny of the justification for and the duration of hospitalization;
- investigate all potential sources of funding for indigent patients;
- decrease in the duration of hospitalization by transfer to a chronic care facility or return to the home setting with or without nursing supervision;
- maximize the utilization of procedures performed in the out-patient setting or as "day-of-surgery" admissions;
- adjust costs for certain services to compensate for revenue lost from others;
- cost-effective purchase of hospital supplies;
- encourage and facilitate cooperation among all hospitals in the community in terms of bed availability and utilization of new, expensive, and technologically sophisticated diagnostic and therapeutic instrumentation;
- establish liaison with health maintenance organizations;
- establish liaison with referring physicians, particularly from underserved rural and inner city urban communities, to provide both compensated and uncompensated care;
- solicit funds from the private sector (corporations, foundations, philanthropic entities, individuals) for the various programs that contribute to the welfare of the community (Table 2); and
- maintain dialogue with legislators at the city, county, state, and federal levels regarding uncompensated care.

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INDIGENT PATIENT CARE
Funds and Expenses



- Indigent Care Expenses
- Municipal Indigent Funds

Figure 1: Indigent patient care funds and expenses, Medical Center, University of South Alabama, 1983-1988.

TABLE 2: CLINICAL PROGRAMS, MEDICAL CENTER,
UNIVERSITY OF SOUTH ALABAMA

Level I Trauma Center	National Institutes of Health/Comprehensive Sickle Cell Disease Center
Regional Burn Center	Accredited Mammography Center
Children's and Women's Hospital	Allergic Diseases Center
National Cancer Institute Member of Southwest Oncology Group and Pediatric Oncology Group	Digestive Diseases Center
Cardiovascular Diseases Center	Computerized Medical Genetics/ Birth Defects Center
Cardiac Rehabilitation Program	Pain Management Clinic
Sleep Disorders Center	Infertility Program
Restorative Care	High-Risk Obstetrical Program
Intensive Care Units:	Child, Adolescent, and Adult Psychiatric Programs
Level III Neonatal Intensive Care	Continuing Medical Educational Program
Medical Intensive Care	Pulmonary Laboratory
Surgical Intensive Care	Aeromedical Helicopter Transport Program
Coronary Intensive Care	Neonatal Transport Unit
Neurotrauma Intensive Care	
Complex Wound Management Center	

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The Medical Center acknowledges its professional responsibility to the community it serves for the provision of health and medical care, education, and research; however, it cannot sustain that commitment without adequate compensation.

SOCIETAL RESPONSIBILITY:

This perspective of the Medical Center/University of South Alabama is not unique, as many public metropolitan academic medical centers have had at least qualitatively similar experiences. That notwithstanding, it is disconcerting to realize that typically an insouciant attitude prevails throughout communities with academic medical centers (Flynt, 1989; Solomon, 1990). Although indigent patient care is often mandated by local governments for any hospital to serve with a community, most private hospitals prefer to limit that commitment, forcing the majority of the indigent patient population upon the academic medical center. One result of this financial burden upon the teaching hospital is a perception by the community of the academic medical center as a "charity hospital." Patients capable of paying for their medical care subsequently avoid and discriminate against the academic medical center. Community hospitals and the general population opt not to be associated with indigent patients and *de facto* deny their existence. Governmental officials are therefore unwilling to address the problem since that would imply expenditure of tax revenues. Denial of the problem further compromises the financial solvency of the academic medical center.

RECOMMENDATIONS:

All academic medical centers responding to the needs of the constituencies they serve will need to address the issues outlined in this essay. The socioeconomic forces operating upon the academic medical center as substantive (Schroeder, *et al.*, 1989). The following recommendations are worthy of consideration as attempts to maintain the financial solvency of these institutions.

First, if the academic medical center is coerced to obey "free-market" economic forces, it should market its product and reap the financial reward of its production. Some institutions have recognized this and embodied it in an aggressive marketing policy. There should be no resentment if the academic medical center competes on the same ground using the same rules as private community hospitals.

Second, the academic medical center should deal with education as its economic product and mandate society to compensate its fair share for educating the physicians it will require. That would necessitate public financial support for indigent patient care.

Third, advanced post-graduate medical education is a privilege not a right, and restriction of specialty and subspecialty educational opportunities is one mechanism of limiting the number of specialists and subspecialists. However, a decrease in the

number of specialists inevitably results in a concomitant increase in cost for each specialists' clinical activities. If reimbursement formulae were modified to represent payment for expertise and not simply payment for technologically-intensive procedures that dichotomy would resolve.

Fourth, medical care could be rationed by prioritizing services for all patients including the indigent. If financial resources for medical care are deemed by society to be finite, then society must bear greater responsibility for the ethical and moral decisions regarding allocation of those funds.

Fifth, the academic medical center could serve as a coordinator of health and medical care throughout a community, facilitating cooperation among physicians, hospitals, and clinics within the academic and private sectors.

Sixth, the academic medical center could focus its clinical programs on entities that are more cost- and labor-intensive, such as critical care, oncology, transplantation, and trauma; while utilizing community-based resources for primary care programs.

Seventh, society must accept its collective participatory and financial responsibilities to support the welfare of the entire community. Medical care professionals must educate their patients and the public in that regard.

Finally, even in the face of mounting pressures from without and within, doctors (L., *doctor*, "teacher") of medicine must reaffirm that the endeavors of an academic medical center represent those of a priestly profession: priestly, because it is dedicated to amelioration of the adversities *conditio humani*; and professional, because it is concerned with the advancement of knowledge and wisdom. To fulfill its obligations and responsibilities - clinical service, education, and research - the academic medical center must remain both philosophically and economically sound.

"Between medicine and the love of wisdom there are no great differences; in fact medicine has all the things that lead toward wisdom:...reverence, modesty, reserve, sound opinion, judgment, calm, steadfastness, purity, knowing speech, knowledge of things useful and necessary for life, the dispensing of that which cleanses, freedom from superstition, preeminence divine."

"Decorum"

Corpus Hippocraticum
(circa 400 B.C.E.)

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LITERATURE CITED:

- Anderson, J. R., 1987. Economics, frigonomics, and medical care: *Alabama Medicine*, v. 56, p. 30-34.
- Association of American Medical Colleges, 1986. *Medical education, institutions, characteristics, and programs. A background paper*: Washington, D.C.
- Berger, D., Bohanan, J., Fabre, H., Graham, D., Hartzes, M., VanMalderen, F., May 18, 1989. Impact of the indigent care crisis on the University of South Alabama Medical Center: Unpublished report prepared for the Office of the Vice-President for Medical Affairs, Medical Center, University of South Alabama, Mobile, Alabama.
- Bettmann, O. L., 1956. *A pictorial history of medicine*: Springfield, Illinois, Charles C. Thomas, Publishers.
- Caper, P., 1986. Cost containment policy: Implications for the future: *Internist*, v. 27, p. 24-28.
- Commonwealth Fund, 1985. *Prescription for change: To preserve the functions of academic health centers for the future*: New York, Harkness House.
- Cumston, C. G., 1987. *An introduction to the history of medicine*: New York, Dorset Press.
- Easterbrook, G., January 26, 1987. The revolution in medicine: *Newsweek*, p. 40-74.
- Enthoven, A. C. (editor), 1988. *Theory & practice of managed competition in health care finance. Lectures in economics: Theory, institutions, policy*: New York, Elsevier Science Publishing Company, Incorporated.
- Flexner, A., 1910, 1972. *Medical education in the United States and Canada: A report to the Carnegie Foundation for the advancement of teaching*: New York, Arno Press.
- Flynt, W., 1989. "We ain't low-down." Poor white society. *Poor but proud. Alabama's poor whites*: Tuscaloosa, Alabama, University of Alabama Press, p. 173-210.

- Freeman, S. A., 1985. Megacorporate health care: A choice for the future: *New England Journal of Medicine*, v. 312, p. 579-582.
- Friedman, R. B., 1984. Impact of the evolution in health care delivery on the academic medical center: *Journal of Medical Education*, v. 59, p. 539-546.
- Garrison, F. H., 1929. *History of medicine*: Philadelphia, WB Saunders & Company.
- Ginzberg, E., 1986. The destabilization of health care: *New England Journal of Medicine*, v. 315, p. 757-761.
- Iglehart, J. K., 1982. Moment of truth for teaching hospitals: *New England Journal of Medicine*, v. 207, p. 132-136.
- Johnson, E. A., 1987. Future effects of financing health care: *Current Surgery*, v. 44, p. 183-189.
- Light, K. W., 1986. Corporate medicine for profit: *Scientific American*, v. 255 p. 38-45.
- Lyons, A. S., Pertrucelli, R. J., II, 1978. *Medicine. An illustrated history*: New York, Harry N. Abrams, Incorporated, Publishers.
- Marks, G., Beatty, W. K., 1973. *The story of medicine in America*: New York, Charles Scribner's Sons.
- Moser, R. H., 1987. The future of American medicine: *Cleveland Clinic Journal of Medicine*, v. 54, p. 67-75.
- Pearl, R., 1925. The distribution of physicians in the U.S.: *Journal of the American Medical Association*, v. 84, p. 1024-1027.
- Petersdorf, R. G., 1981. Academic medicine: No longer threadbare or genteel: *New England Journal of Medicine*, v. 304, p. 841-843.
- Raffel, M. W., Raffel, N. K., 1989. *The U.S. health system: Origins and functions*. Third Edition: New York, John Wiley & Sons.
- Relman, A. S., 1984. Who will pay for medical education in our teaching hospitals?: *Science*, v. 226, p. 20-23.
- Rodning, C. B., 1987. University hospitals: Historical precedents: *Pharos*, v. 50, p. 28-29.

Academic Medical Centers

- Rodning, C. B., Dacso, C. C., 1987. Realistic expectations of a patient-physician encounter: *Southern Medical Journal*, v. 80, p. 1208-1209.
- Rodning, C. B., 1989. Medical College of Alabama in Mobile, 1859-1920: A legacy of Dr. Josiah Clark Nott: *Southern Medical Journal*, v. 82, p. 53-63.
- Rogers, D. E., Blendon, R. J., 1978. The academic medical center: A stressed American institution: *New England Journal of Medicine*, v. 299, p. 940-953.
- Salley, R. K., Rodning, C. B., 1989. Inception of a matronized nursing service at the Mobile City Hospital in the mid-nineteenth century: A paradigm of altruism and indigent patient care: *Southern Medical Journal*, v. 82, p. 1017-1025.
- Schroeder, S. A., Jones, J. S., Showstack, J. A., 1989. Academic medicine as a public trust: *Journal of the American Medical Association*, v. 262, p. 803-812.
- Solomon, R. C., 1990. *Passion for justice*: Redding, Massachusetts, Addison-Wesley Publishing Company, Incorporated.
- Starr, P., 1977. Medicine, economy, and society in nineteenth century America: *Journal of Social History*, v. 10, p. 588-607.
- Starr, P., 1978. Medicine and the waning of professional sovereignty: *Daedalus*, v. 107, p. 175-193.
- Starr, P., 1982. *The social transformation of American medicine*: New York, Basic Books, Incorporated.
- Taksel, L., Jolly, P., Beran, R., 1989. US medical school finances: *Journal of the American Medical Association*, v. 262, p. 1020-1028.
- Turner, B. R., 1989. Future roles of academic medical centers: *Health Care Management Review*, v. 14, p. 73-77.
- Wangensteen, O. H., Wangensteen, S. D., 1978. *The rise of surgery from empiric craft to scientific discipline*: Minneapolis, University of Minnesota Press.
- Watt, J. M., Derzon, R. A., Renn, S. C., 1986. The comparative economic performance of investor-owned chain and not-for-profit hospitals: *New England Journal of Medicine*, v. 314, p. 89-96.
- Wilson, M. P., McLaughlin, C. P., 1984. *Leadership and management in academic medicine*: Association of American Medical Colleges, Washington, D.C.

THE LOST OF WETLANDS IN THE URBANIZED AREA OF MADISON
COUNTY, ALABAMA--1979-89, AND FACTORS CONTRIBUTING
THERETO¹

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INTRODUCTION

Wetlands, including inland, coastal, freshwater and salt water types, are recognized as some of the most important ecosystems on the earth today. Their importance is being given increasingly greater attention as ecologists, engineers, planners, government agencies, interest groups, and the public at large become aware of wetlands' invaluable contribution of life. Any research on wetlands should be preceded by a definition of what they are, as too often it is not clear what constitutes a wetland.

There are three main components in any wetland definition (Mitsch and Gosselink 1986, 15-16):

1. the presence of water at least periodically;
2. soils that differ from those of the adjacent uplands; and
3. vegetation that is adapted to wet conditions and tolerant to flooding.

Any accepted definition is often dependent upon the purpose or objective for which it is needed. Where the objective is to determine boundaries so that wetlands can be inventoried, evaluated and managed properly, a multidisciplinary approach, as used by the U.S. Fish and Wildlife Service (FWS), is most meaningful. This definition is widely accepted as the national standard for identifying wetlands and is used for the purpose of this research.

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification, wetlands must have one or more of the following three attributes:

- (1) at least periodically, the land supports predominantly hydrophytes;

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- (2) the substrate is predominantly undrained hydric soils; or
- (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al. 1979, 3).

The Values of Wetlands

The values and functions of wetlands are as many and varied as the types of wetlands themselves. Their value as a fish and wildlife preserve has been a traditional one, and for decades this was the only value accorded them. It is only recently that recognition has been given to the many other vital functions performed by wetlands. Wetlands:

1. Serve as fish and wildlife preserves;
2. Facilitate the formation of some fossil fuels (mainly coal and natural gas);
3. Cleanse polluted waters and are natural purification systems for the hydrological and chemical cycles;
4. Moderate floods, protect shorelines, and recharge water to aquifers;
5. Help maintain fish populations;
6. Provide permanent habitats for birds and other wildlife including a number of endangered species; and are breeding, wintering and feeding grounds for migratory waterfowl and other birds;
7. Offer protective cover from predators and hostile environmental change;
8. Serve as sources of surface and ground water supplies;
9. Help reduce flooding, erosion, and storm drainage;
10. Yield numerous natural products, e.g. timber, peat, cranberries, blueberries, wild rice, and fur;
11. Facilitate and enhance educational and scientific research;
12. Provide outdoor recreation -- boating, fishing, hunting, hiking, bird watching, nature observation, and photography.

This list supports the fact that wetlands are indeed a vital part of the environment. The trend of wetlands destruction in the Urbanized Area of Madison County will not only have repercussions on the local environment, but on the regional

The Loss of Wetlands in the Urbanized Area of Madison County

and national environment as well. Their loss will contribute to an eroding of a part of America's natural heritage, lessening its economic well-being and its quality of life. It is on this premise that this research was conducted.

It was not until the 1970's that interest in wetlands protection began to surface, when scientists took the initiative to identify and quantify the many values of this ecosystem. It was then that federal and state programs were designed to protect wetlands as environmentally vital areas. Nevertheless, wetland loss continues at a rate of nearly 0.5 million acres per year (Tuxill 1990, 43).

The Study

The purpose of this research was to document the extent to which wetlands of five or more acres have been lost within the Urbanized Area of Madison County, Alabama between 1979 and 1989, and to identify some of those activities which have contributed to the loss.

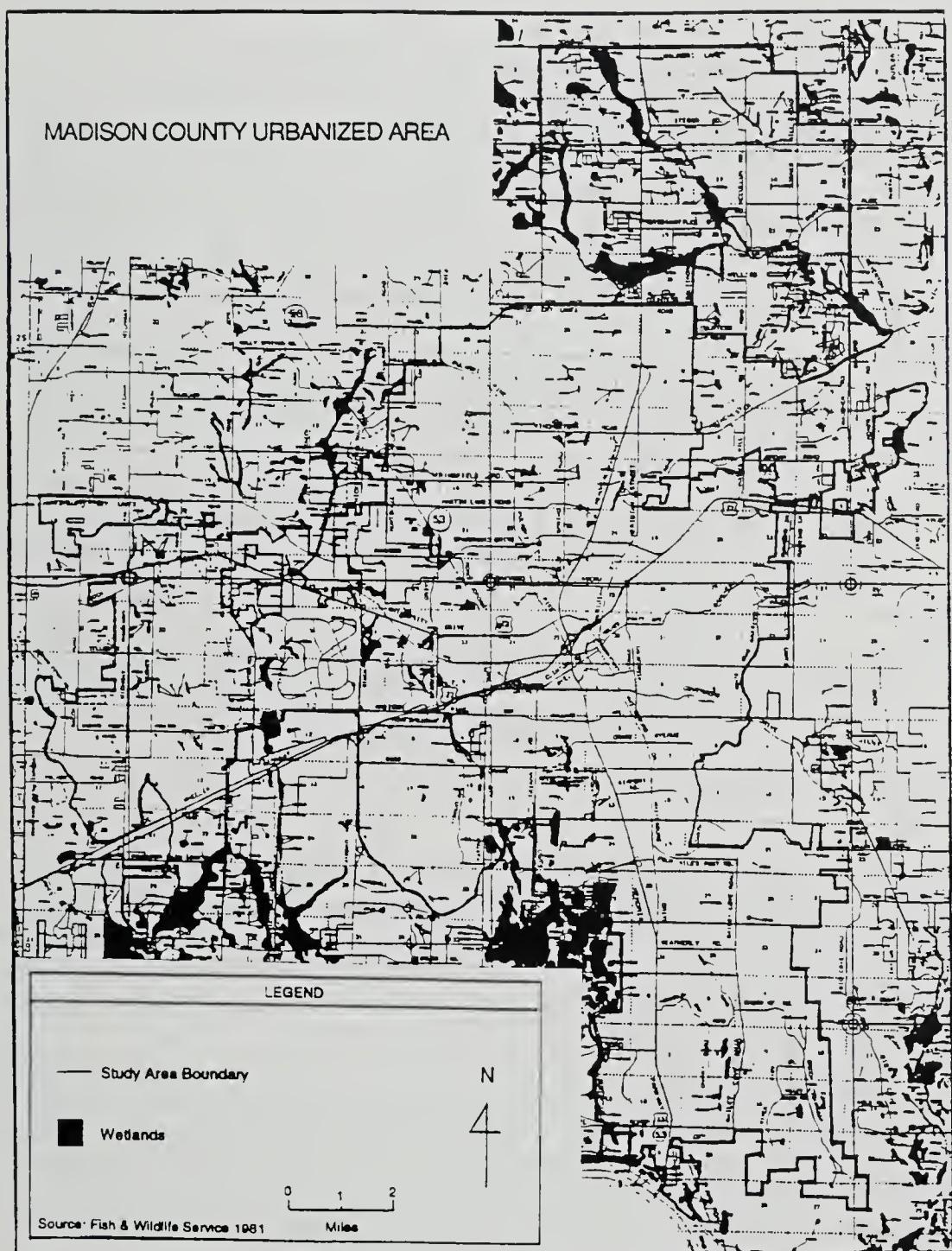
Another reason for undertaking this research was to alert people to the long-term effects of wetland loss. Because there is no documentation of this phenomenon in Madison County, these findings may well be of benefit to many local and regional planners, environmentalists, and the general public. As an original study, this research will add significantly to the body of knowledge on the subject of wetland loss from the planner's point of view.

The Area

The designated study area boundary, as shown in Figure 1, was established by the Census Bureau based on the findings of the 1990 Census of Population and Housing. The study area covers an estimated 148.59 square miles and houses a population of 177,987 (Census Bureau 1990).

The study area was chosen for a number of reasons. Madison County Urbanized Area has undergone significant growth in the past 10 to 15 years. It is the fastest growing county in the state of Alabama and one of the fastest growing in the southern United States. These changes have impacted both the natural and built environments, and there are visible signs that wetland loss has occurred, although this has not been documented. Hence, there is a need for careful analysis of the extent to which growth and other factors have led to loss of wetlands in this area.

In light of the ecological and recreational values discussed above, documentation on the rapid loss of wetlands is necessary if they are to be saved. The regulatory agencies, developers, planners, environmentalists and the general public must become cognizant of the unwarranted loss of "nature's kidneys" as it applies to the study area.



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Figure 1. Wetlands of the Urbanized Area of Madison County, 1979.

The Loss of Wetlands in the Urbanized Area of Madison County

PROCEDURE

Four tasks were undertaken in order to complete this research.

Task 1: National Wetlands Inventory (NWI) maps were used to identify the extent of the area's wetland resources in 1979 using five acres as the minimum site size. The maps served as the base maps because they are the first and to date the only inventory of Madison County wetlands. The minimum site size is based on the NWI criteria used to inventory wetlands in Madison County. Only sites of five or more acres were consistently mapped (Storrs 1991).

Task 2: To identify and determine the extent of the area's wetlands in 1989, the latest available aerial photographs provided by the Madison County Agricultural Stabilization and Conservation Service (ASCS) were used.

Task 3: The 1979 wetlands were digitized using the ERDAS software. Wetland acreages were computed and displayed. The area's wetland resources for 1989 were arrived at by combining photographic data with NWI map data, and a 1989 wetlands map of the area created.

Task 4: To identify those land uses which have replaced wetlands over the period, both photographic interpretation and site investigations were utilized.

RESULTS AND DISCUSSION

Wetland Losses: 1979-89

In 1979, the study area had an estimated total wetland acreage of 2,795.98. By 1989, there were 2,646.63 acres of wetlands. Between 1979 and 1989 the area lost 149.35 acres of its wetlands, reflecting a 5.34 percentage loss over the eleven year period. This approximated to an annual loss of 0.5%. If this rate of loss is allowed to continue, in less than 2 centuries the entire wetland resources of the study area will be lost.

A total of 139 sites were initially identified in the study area as comprising five or more acres of undisturbed wetlands in 1979. Over the eleven year period on which the study is based, 22 sites had lost some or all of their wetlands to agricultural or urban development. These were direct losses due to either drainage, fill, or both.

The southern sector of the study area lost the least amount of wetlands over the period under investigation. The central and western sectors of the study area experienced the greatest amount of wetland destruction over the 1979-89 period. In these sectors the loss was usually total site loss.

Factors Contributing to Wetland Losses

Growth translates into new land uses, including commercial, industrial, residential and highway construction, and agricultural development, all of which have replaced wetlands over the years. Table 1 shows in detail the extent to which the various types of developments have contributed to the loss of wetlands in the Madison County Urbanized Area from 1979 to 1989.

Table 1. Land Uses Contributing to Wetland Loss in the Urbanized Area of Madison County, 1979-89.

LAND USE	ACRES	PERCENT
Commercial	58.62	39.25
Residential	36.55	24.47
Highway	29.11	19.49
Industrial	14.93	10.00
Agriculture	10.14	6.79
TOTAL	149.35	100.00

Source: Computed from data provided through aerial photos and site visits

Field investigation showed that the majority of the urban development activity contributing to wetland losses was commercial. This development is clustered around the Jordan Lane/University Drive area -- a commercial corridor located in the central portion of the study area. The growth thrust for the study area coincides with the areas that experienced the greatest loss. Commercial land use is responsible for the loss of 58.62 acres or 39.25% of the area's wetland losses. This is followed by residential development which accounts for the loss of 36.55 acres (24.47%) of the area's wetlands. Agricultural use, on the other hand, accounts for only 6.79% of the loss and is concentrated in the northern section of the study area.

The replacement of wetlands by residential land use is most prominent in the north central and south west areas. The south western portion of the study area is within Madison city limits -- the fastest growing city in the state of Alabama. The research shows that due to the rapid population growth and demand for new housing over the period under investigation, wetland losses within Madison city limits occurred as a result of residential and infrastructural development.

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CONCLUSION

The research shows that 149.35 acres or 5.34% of the wetlands within the Urbanized Area of Madison County were lost between 1979 and 1989. This loss was due mainly to urban development and expansion which occurred during the 1980's. Commercial and residential land uses were responsible for most of the area's wetland losses -- 95.17 acres, a total of 63.72%. When compared to urban development, agricultural development had a relatively small impact on wetland losses in the study area.

Public education is paramount to the survival of the remaining wetlands within the study area. If the public is to be effective in helping to preserve our wetland resources, it must be educated in regards to the values of wetlands and the part it (the public) can play in ensuring that such a vital ecosystem is kept in tact.

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LITERATURE CITED

- Census of Population and Housing, Alabama 1990.* U. S. Department of Commerce. 1990.
- Cowardin, Lewis M., V. Carter, F. C. Golet and E. T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* FWS/OBS-31, Washington, D.C.: USFWS.
- Mitsch, W. J. and James Gosselink. 1986. *Wetlands.* New York: Van Nostrand Reinhold.
- Storrs, Charley, U. S. fish and Wildlife Service, NWI Coordinator. 1991. Personal communication, November 13.
- Tuxill, Jacquelyn. 1990. "Wetlands at the Crossroads." *The Environment Magazine,* (May-June): 43-45.

A REVIEW OF THE CRITICAL EVENTS LEADING TO
MESODERM INDUCTION IN *XENOPUS*¹

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The emergence of a complex, sentient animal from a single fertilized egg cell is a phenomenon almost beyond belief. Yet, vertebrate animals are living proof that such a developmental scheme does exist. Of all the thousands of steps in the process of vertebrate development, one of the first is the elaboration of axial mesoderm. In amphibian embryos, all mesoderm arises from animal pole cells that have been induced to change their fate by vegetal pole cells (Nieuwkoop, 1969). Some of these vegetal pole cells possess the unique ability to induce dorsal mesodermal structures, such as somite and the notochord (Smith and Slack, 1983; Gimlich and Gerhart, 1984; Stewart and Gerhart, 1990). What is the effect of vegetal pole cells on animal pole cells? Why is one region of mesoderm different from another? What are the signals that instruct these differences? This paper outlines the critical events that lead to the induction of axial mesoderm in the genus *Xenopus*. (For a review of mesoderm induction in mammals and *Drosophila* see Stern *et al.*, 1992 and Leptin *et al.*, 1992). Beginning with the foundation laid by cortical rotation in the *Xenopus* egg, a review of the spatial and temporal relationships between animal and vegetal cell types is followed by a discussion of some of the likely chemical mediators of mesodermal induction.

Cortical Rotation of the Xenopus Egg

A profound change in the organization of the cytoplasm in the *Xenopus* egg occurs within the first 100 minutes after fertilization. The outer cortex of the egg rotates approximately 30° relative to the inner cytoplasm (Gerhart *et al.*, 1989; Danilchik and Denegre, 1991; Houliston and Elinson, 1991a). Visual evidence of rotation appears in the eggs of *Rana* species where, before rotation, the gray core pigment of the animal pole cytoplasm is hidden under the black pigment of the animal pole cortex; however, after rotation some of the gray pigment becomes visible through the clear cortex of the vegetal pole, creating the appearance of the gray crescent (Gerhart *et al.*, 1989). Microtubules form parallel arrays at the cortical surface of the vegetal hemisphere, and kinesin may be involved in the rotational movement (Elinson and Rowning, 1988; Houliston and Elinson, 1991b). Disruption of microtubule assembly by drugs, such as colchicine or nocodazole, or by physical factors, such as ultraviolet irradiation of the vegetal hemisphere or cold shock, can prevent cortical rotation from occurring (Scharf and Gerhart, 1980; Elinson and Rowning, 1988; Gerhart *et al.*, 1989).

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The importance of cortical rotation to the further development of the embryo is illustrated by experiments that halt rotation. When rotation fails to occur, the embryo fails to develop any dorsal features, retains its cylindrical symmetry and consists of just ventral cell types, such as blood islands, epidermis, and a short intestine (Gerhart *et al.*, 1989; Stewart and Gerhart, 1990). More significant, though, is the fact that replacing two vegetal cells from a UV irradiated embryo with two vegetal cells from the region adjacent to the gray crescent region of a non-irradiated 32-64 cell stage embryo "rescues" the irradiated embryo from its ventralized fate (Gimlich and Gerhart, 1984; Gerhart *et al.*, 1989; Stewart and Gerhart, 1990). Alternatively, rotation in a UV irradiated embryo can be achieved by gravitational means, and the embryo goes on to develop a normal dorsal axis (Scharf and Gerhart, 1980). These results indicate that cortical rotation is a fundamental step in normal amphibian development that results in a change in the character of the cytoplasm in the vegetal cells adjacent to the gray crescent area. Thus, the cells that eventually contain that cytoplasm also possess the ability to induce the formation of dorsal axial structures.

Vegetal and Animal Pole Relationships

Cortical rotation alone is not sufficient to induce mesodermal structures, however (Nieuwkoop, 1969; Gurdon *et al.*, 1985). The *Xenopus* blastula is divided into an animal pole and a vegetal pole and the spatial and temporal relationships between these two cell types are crucial for normal development. Animal pole cells that are cultured alone just form epidermis, an ectodermal derivative (Jones and Woodland, 1987), while vegetal pole cells in isolation form only endodermal structures (Nieuwkoop, 1969). However, when the two cell types are cultured together, the animal cells express actin mRNA, a mesodermal marker (Gurdon *et al.*, 1985). In addition, when animal pole cells are grafted onto vegetal cells, mesodermal structures such as muscle and notochord form (Nieuwkoop, 1969; Jones and Woodland, 1987). Using two *Xenopus* species that are histologically distinguishable, Jones and Woodland (1987) demonstrated that the mesodermal tissue is derived solely from the animal pole cells that are induced by vegetal cells. Vegetal cells have been shown to be capable of inducing mesoderm in animal cells as early as stage 6 (32-cell stage), continuing through stage 10½ (early gastrula). Animal cells are able to respond to vegetal cells by stage 6½ and lose competence by stage 10½ (Gurdon *et al.*, 1985; Jones and Woodland, 1987). Thus, by the mid blastula stage (stage 8), vegetal cells are able to induce equatorial animal cap cells to form mesodermal tissue, instead of the epidermis they would form if cultured in isolation (Nieuwkoop, 1969; Smith and Slack, 1983; Smith *et al.*, 1989). The vegetal cells themselves have differential abilities to induce mesoderm formation. Ventral vegetal cells induce ventral types of mesoderm, such as blood islands, while dorsal vegetal cells induce dorsal axial mesoderm structures, such as somites and notochord (Smith and Slack, 1983; Dale *et al.*, 1985; Smith *et al.*, 1989). Ventral vegetal cells that are transplanted

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into the dorsal organizer region of UV irradiated embryos are unable to induce axis formation, while transplanted dorsal vegetal cells are able to induce normal development in UV irradiated embryos (Gimlich and Gerhart, 1984).

The unique ability of the dorsal vegetal cells to induce dorsal mesodermal structures relates back to cortical rotation. When rotation is less than 30°, there is incomplete formation of dorsoanterior structures (Gerhart *et al.*, 1989). This relationship of the amount of dorsal vegetal inducer to the extent of dorsoanterior development was demonstrated by grafting varying amounts of dorsal animal-vegetal tissue, or organizer tissue, onto UV irradiated embryos; it was shown that there is a minimum amount of dorsal organizer tissue required to successfully induce a normal axis (Stewart and Gerhart, 1990).

Ventral and Dorsal Mesoderm Inducing Factors

The evidence presented demonstrates that dorsal and ventral vegetal cells are qualitatively different in the type of mesoderm they can induce. This would suggest that the signals they elaborate are also different, and the data presently available indicate that at least two factors are at work. Until recently, the most likely candidate for the ventral mesodermalizing factor was basic fibroblast growth factor (bFGF) (Slack *et al.*, 1989; Christian *et al.*, 1992); however, a new FGF, *Xenopus* embryonic FGF (XeFGF) appears more promising as the ventral mesoderm inducer (Isaacs *et al.*, 1992). The best candidate for the dorsalizing factor is Activin B (Thomsen *et al.*, 1990; Nakamura *et al.*, 1992).

Putative Ventral Mesoderm Inducer: FGF

Fibroblast growth factor was first suspected as a factor in development when Jacobovits and others (1986) discovered that a gene for FGF (*wnt-2*; Nusse *et al.*, 1991) was activated by insertion of the mouse mammary tumor virus into the mouse genome. The proto-oncogene *wnt-2* is not normally expressed in the adult animal but transcripts are found in the early gastrula and are associated with cell migration (Slack *et al.*, 1987; Dickson and Peters, 1987; Sudol, 1988; Wilkinson *et al.*, 1988). A basic FGF-like molecule has also been isolated in *Xenopus* blastulae (XeFGF) (Slack *et al.*, 1989; Isaacs *et al.*, 1992), indicating that this molecule may be implicated in *Xenopus* development, as well.

Although basic FGF (bFGF) does not have a signal sequence for secretion from the vegetal cell (Slack *et al.*, 1989), XeFGF does have such a sequence and behaves like a secretory molecule (Isaacs *et al.*, 1992), as would be expected from a molecule that is to have an effect on surrounding cells. In explant experiments, bFGF at a concentration as low as 2 ng/ml is able to induce mesoderm formation by animal cap cells, but it is usually the more ventral mesodermal structures, such as muscle (Slack *et al.*, 1987; Christian *et al.*, 1992). At high concentrations, bFGF occasionally induces notochord formation (Slack *et al.*, 1989). XeFGF has mesoderm-

inducing properties similar to bFGF (Isaacs *et al.*, 1992). This pattern of induction suggests that FGF, possibly XeFGF, is the ventral mesodermalizing factor (Slack *et al.*, 1989; Christian *et al.*, 1992; Isaacs *et al.*, 1992).

In order to function as an endogenous inducer though, FGF must not only cause mesoderm formation, but also must be present at the correct time during development, and at a sufficient concentration. In addition, the responding tissue must express a receptor for FGF at the appropriate time. Both maternal and zygotic XeFGF mRNA have been identified (Isaacs *et al.*, 1992) and a mesoderm-inducing molecule has been purified from the *Xenopus* blastula at a concentration of 10 ng/ml, which is a quantity sufficient to induce ventral mesoderm (Slack *et al.*, 1989). Thus, some form of FGF is available at the right time and in the right amount to influence induction and XeFGF fits the criteria for the endogenous ventral mesoderm inducer. Basic FGF, on the other hand, is found in the cytoplasm, instead of in the extracellular space at the time of mesoderm induction (Shiurba *et al.*, 1991). A receptor that binds FGF has been cloned from the *Xenopus* oocyte and embryo and, like other FGF receptors, is a transmembrane protein with tyrosine kinase activity (Musi *et al.*, 1990). The levels of FGF receptor in the responding tissue, animal cap ectoderm, rise to a maximum in the mid blastula stage (stage 8) and then gradually decrease, as shown by ^{125}I -acidic FGF binding (Gillespie *et al.*, 1989). This corresponds to the pattern of competence seen in explants of animal cap cells (Gurdon *et al.*, 1985; Jones and Woodland, 1987) which lends further support to FGF as the ventral mesoderm inducer.

Putative Dorsal Mesoderm Inducer: Activin

Induction of the dorsal mesodermal structures by dorsal vegetal cells apparently requires a signal different from FGF, since FGF cannot induce dorsal mesoderm except at very high concentrations. In 1987, Smith described a mesoderm-inducing factor (MIF) secreted by the *Xenopus* cell line XTC (Smith, 1987). The XTC-MIF was shown to be a dimeric protein and a member of the transforming growth factor- β (TGF- β) family (Smith *et al.*, 1988). While FGF needs to be in concentrations greater than 1 $\mu\text{g}/\text{ml}$ to induce dorsal axial structures, XTC-MIF can induce dorsal mesoderm at a concentration of 25 ng/ml (Smith *et al.*, 1988). Furthermore, animal cap ectoderm that has been treated with XTC-MIF can induce dorsal mesoderm formation when it is transplanted into the ventral marginal zone of the blastula, a region that does not normally contribute to dorsal mesodermal structures (Smith *et al.*, 1989). Thus, XTC-MIF makes a strong case for being the dorsalizing agent of the dorsal vegetal cells. However, XTC-MIF is isolated from a highly artificial environment, an animal cell line, and any statements made about its activity must be evaluated in light of that fact.

Knowing that XTC-MIF is in the TGF- β family, Asashima and others (1990) tested the mesoderm-inducing properties of other TGF- β molecules. They found that human Activin A can induce notochord, muscle and mesenchyme in explants. In fact,

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human Activin A and XTC-MIF appear to be homologues based on the fact that, like Activin A, XTC-MIF has erythroid differentiation activity and follicle-stimulating hormone-releasing activity (Smith *et al.*, 1990; van den Eijnden-Van Raaij *et al.*, 1990). Subsequently, Asashima and colleagues (1991) were able to isolate an activin homologue from *Xenopus* eggs and blastulae; however, mRNA transcripts for *Xenopus* Activin A do not appear in the embryo until the late gastrula stage (Thomsen *et al.*, 1990) and animal cap cells lose the ability to respond to the vegetal cell signal at the start of the gastrula stage (Jones and Woodland, 1987). As a result, the requirement that the putative mesoderm inducer be present at the appropriate time is not met by Activin A/XTC-MIF. While Activin A may still be a factor in *Xenopus* development, it is not likely to be the endogenous dorsalizing agent secreted by dorsal vegetal cells (Thomsen *et al.*, 1990).

On the other hand, Activin B is another member of the activin gene family and its mRNA is found in *Xenopus* embryos at the late blastula stage (stage 9) (Thomsen *et al.*, 1990). Like other members of the TGF- β group, Activin B is a dimeric protein of $M_r \sim 25,000$. It exists at the same concentration in the cells as Activin A (Nakamura *et al.*, 1992), but its activity in the FSH-stimulation assay and erythroid differentiation assay is lower than that of Activin A. As a mesodermal inducer, though, Activin B is as potent as Activin A and can induce a secondary axis when its mRNA is injected into a ventral blastomere of a 32-cell embryo (Nakamura *et al.*, 1992; Thomsen *et al.*, 1992). Using a mouse RNA probe, Mathews and others (1992) identified a cDNA in *Xenopus* that codes for an activin receptor (xActRII). The mRNA for this receptor is found in the egg and all the embryonic stages. The receptor has serine/threonine kinase activity (Hemmati-Brivanlou and Melton, 1992). Since Activin A and B are expressed at different times during development, this suggests that Activin A and B perform different functions during *Xenopus* development (Nakamura *et al.*, 1992). Activin B may be the dorsalizing signal for mesoderm induction, while Activin A may signal some other change in cellular differentiation.

Conclusions and Implications

Many molecules in the FGF and TGF- β families have mesoderm-inducing properties, but the most compelling candidates known to date for mesoderm inducers are XeFGF for the ventral mesoderm signal and Activin B for the dorsal mesoderm signal. The early developmental event of cortical rotation appears to be indispensable for organizing the future dorsoventral axis as seen by the effect of rotation on the expression of dorsal mesodermal structures. Thus, while the evidence suggests that FGF potentially can have effects throughout the blastula, with or without cortical rotation (Slack *et al.*, 1988; Gerhart *et al.*, 1989; Gillespie *et al.*, 1989; Smith *et al.*, 1989), the dorsal mesoderm structures are not induced to form if rotation fails to occur (Gerhart *et al.*, 1989).

Although information about signal transduction during the next phase of development, neural induction, is readily available (see Slack and Tannahill, 1992 for a review), little is known at this time about the signal transduction pathways activated in animal cap ectoderm by the FGF and Activin B receptor kinases. Presumably these receptors promote phosphorylation of cytoplasmic proteins that initiate a cascade of effects. The FGF receptor is known to be a tyrosine kinase receptor. Whitman and Melton (1990) demonstrated that tyrosine phosphorylation is sufficient to induce mesoderm formation by expressing a viral oncogene that is known to activate tyrosine kinase in *Xenopus* embryos. The gene product subsequently induced animal cap ectoderm to form mesoderm. The *Xenopus* Activin A receptor is a serine/threonine kinase, while that of the mouse has serine/threonine/tyrosine kinase activity (Nakamura *et al.*, 1992). Activin A may act by a mechanism similar to that of lithium. Lithium chloride is known to mimic the dorsal mesoderm inducer and direct the formation of dorsal axial structures, perhaps by its effect on the polyphosphoinositide cycle (Busa and Gimlich, 1989; Christian *et al.*, 1992). Or the pathway may be one such as that discovered in mouse embryo cells (Nånberg *et al.*, 1990). At mitogenic doses, bFGF stimulates phosphorylation of a protein known to be a substrate of protein kinase C, but no accumulation of inositol triphosphate or calcium is detectable (Nånberg *et al.*, 1990).

At the level of protein expression, one of the effects of these signal transduction pathways is the expression of the *Xenopus Brachyury* (Xbra) gene in cells of the blastopore lip (Smith *et al.*, 1991). This gene was originally described in the mouse where its mutant form results in abnormal notochord development (Wilkinson *et al.*, 1990; Smith *et al.*, 1991). Both Activin and bFGF can induce expression of Xbra and its effects seem to specify posterior mesoderm (Cunliffe and Smith, 1992).

Another interesting correlation with the onset of mesoderm induction is the restriction of gap junctional coupling to communication between cells having similar fates (Guthrie and Gilula, 1989). In fact, dorsal-fate cells have more permeable gap junctions than ventral-fate cells (Nagajski *et al.*, 1989), and injection of Activin B into ventral blastomeres of 32-cell stage *Xenopus* embryos increases the gap junction permeability of these ventral-fate cells (Olson and Moon, 1992). This gap junctional asymmetry between dorsal- and ventral-fate cells may be a consequence of an inducing-signal effect (Nagajski *et al.*, 1989).

In summary, the process of mesoderm induction in *Xenopus* species requires the cortical rotation event in the egg, the elaboration of inducer signals, perhaps XeFGF and Activin B at least, and the expression of receptors on the target cells. The precise effects of these molecules and the possibility that other signals are acting concurrently are questions yet to be answered.

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REFERENCES

- Asashima, M., Nakano, H., Shimada, K., Kinoshita, K., Ishii, K., Shibai, H., and Ueno, N. 1990. Mesodermal induction in early amphibian embryos by activin A (erythroid differentiation factor). *Roux's Archives of Developmental Biology* 198:330-335.
- Asashima, M., Nakano, H., Uchiyama, H., Sugin, H., Nakamura, T., Eto, Y., Ejima, D., Nishimatsu, S., Ueno, N., and Kinoshita, K. 1991. Presence of activin (erythroid differentiation factor) in unfertilized eggs and blastulae of *Xenopus laevis*. *Proceedings of the National Academy of Sciences of the USA* 88:6511-6514.
- Busa, W. and Gimlich, R. 1989. Lithium-induced teratogenesis in frog embryos prevented by a polyphosphoinositide cycle intermediate or a diacylglycerol analog. *Developmental Biology* 132:315-324.
- Christian, J., Olson, D., and Moon, R. 1992. *Xwnt-8* modifies the character of mesoderm induced by bFGF in isolated *Xenopus* ectoderm. *The EMBO Journal* 11:33-41.
- Cunliffe, V. and Smith, J. 1992 Ectopic mesoderm formation in *Xenopus* embryos caused by widespread expression of a *Brachyury* homologue. *Nature* 358:427-430.
- Dale, L., Smith, J. and Slack, J. 1985. Mesoderm induction in *Xenopus laevis*: a quantitative study using a cell lineage label and tissue-specific antibodies. *Journal of Embryology and Experimental Morphology* 89:289-312.
- Danilchik, M. and Denegre, J. 1991. Deep cytoplasmic rearrangements during early development in *Xenopus laevis*. *Development* 111:845-856.
- Dickson, C. and Peters, G. 1987. Potential oncogene product related to growth factors. *Nature* 326:833.
- Elinson, R. and Rowning, B. 1988. A transient array of parallel microtubules in frog eggs: Potential tracks for a cytoplasmic rotation that specifies the dorso-ventral axis. *Developmental Biology* 128:185-197.
- Gerhart, J., Danilchik, M., Doniach, T., Roberts, S., Rowning, B. and Stewart, R. 1989. Cortical rotation of the *Xenopus* egg: consequences for the anteroposterior pattern of embryonic dorsal development. *Development Suppl.* pp 37-51.
- Gillespie, L., Paterno, G. and Slack, J. 1989. Analysis of competence: receptors for fibroblast growth factor in early *Xenopus* embryos. *Development* 106:203-208.

- Gimlich, R. and Gerhart, J. 1984. Early cellular interactions promote embryonic axis formation in *Xenopus laevis*. *Developmental Biology* 104:117-130.
- Gurdon, J., Fairman, S., Mohun, T. and Brennan, S. 1985. Activation of muscle-specific actin genes in *Xenopus* development by an induction between animal and vegetal cells of a blastula. *Cell* 41:913-922.
- Guthrie, S. and Gilula, N. 1989. Gap junctional communication and development. *Trends In Neuroscience* 12:12-16.
- Hemmati-Brivanlou, A. and Melton, D. 1992. A truncated activin receptor inhibits mesoderm induction and formation of axial structures in *Xenopus* embryos. *Nature* 359:609-614.
- Houliston, E. and Elinson, R. 1991a. Patterns of microtubule polymerization relating to cortical rotation in *Xenopus laevis* eggs. *Development* 112:107-117.
- Houliston, E. and Elinson, R. 1991b. Evidence for the involvement of microtubules, ER, and kinesin in the cortical rotation of fertilized frog eggs. *Journal of Cell Biology* 114:1017-1028.
- Isaacs, H., Tannahill, D. and Slack, J. 1992. Expression of a novel FGF in the *Xenopus* embryo. A new candidate inducing factor for mesoderm formation and anteroposterior specification. *Development* 114: 711-720.
- Jakobovits, A., Shackleford, G., Varmus, H. and Martin, G. 1986. Two proto-oncogenes implicated in mammary carcinogenesis, *int-1* and *int-2*, are independently regulated during mouse development. *Proceedings of the National Academy of Sciences of the USA* 83:7806-7810.
- Jones, E. and Woodland, H. 1987. The development of animal cap cells in *Xenopus*: a measure of the start of animal cap competence to form mesoderm. *Development* 101:557-563.
- Kimelman, D. and Kirschner, M. 1987. Synergistic induction of mesoderm by FGF and TGF- β and the identification an mRNA coding for FGF in the early *Xenopus* embryo. *Cell* 51:869-877.
- Leptin, M., Casal, J., Grunewald, B. and Reuter, R. 1992. Mechanisms of early *Drosophila* mesoderm formation. *Development Supplement* pp. 23-31.
- Mathews, L., Vale, W. and Kintner, C. 1992. Cloning of a second type of activin receptor and functional characterization in *Xenopus* embryos. *Science* 255:1702-5.

Mesoderm Induction in *Xenopus*

- Musci, T., Amaya, E. and Kirschner, M. 1990. Regulation of the fibroblast growth factor receptor in early *Xenopus* embryos. *Proceedings of the National Academy of Sciences of the USA* 87:8356-8369.
- Nagajski, D., Guthrie, S., Ford, C. and Warner, A. 1989. The correlation between patterns of dye transfer through gap junctions and future developmental fate in *Xenopus*: the consequences of u.v. irradiation and lithium treatment. *Development* 105:747-752.
- Nakamura, T., Asashima, N., Eto, Y., Takio, K., Uchiyama, H., Moriya, N., Ariumi, T., Yashiro, T., Sugino, K., Titani, K. and Sugino, H. 1992. Isolation and characterization of native Activin B. *Journal of Biological Chemistry* 267:16385-16389.
- Nakamura, T., Sugino, K., Kurosawa, N., Sawi, M., Takio, K., Eto, Y., Iwashita, S., Muramatsu, M., Titani, K., and Sugino, H. 1992. Isolation and characterization of Activin Receptor from mouse embryonal carcinoma cells. *Journal of Biological Chemistry* 267:18924-18928.
- Nånberg, E., Morris, C., Higgins, T., Vara, F. and Rozengurt, E. 1990. Fibroblast Growth Factor stimulates protein kinase C in quiescent 3T3 cells without Ca²⁺ mobilization or inositol phosphate accumulation. *Journal of Cellular Physiology* 143:232-242.
- Nieuwkoop, P. 1969. The formation of the mesoderm in urodelean amphibians. I. Induction by the endoderm. *Wilhelm Roux' Archiv* 162:341-373.
- Nusse, R., Brown, A., Papkoff, J., Scambler, P., Shackleford, G., McMahon, A., Moon, R. and Varmus, H. 1991. A new nomenclature for *int-1* and related genes: The *Wnt* gene family. *Cell* 64:231.
- Olson, D. and Moon, R. 1992. Distinct effects of ectopic expression of *Wnt-1*, Activin B, and bFGF on gap junctional permeability in 32-cell *Xenopus* embryos. *Developmental Biology* 151: 204-212.
- Scharf, S. and Gerhart, J. 1980. Determination of the dorsal-ventral axis in eggs of *Xenopus laevis*: complete rescue of uv-impaired eggs by oblique orientation before first cleavage. *Developmental Biology* 79:181-197.
- Shiurba, R., Jing, N., Sakakura, T., and Godsave, S. 1991. Nuclear translocation of fibroblast growth factor during *Xenopus* mesoderm induction. *Development* 113:487-493.
- Slack, J., Darlington, R., Heath, J. and Godsave, S. 1987. Mesoderm induction in early *Xenopus* embryos by heparin-binding growth factors. *Nature* 326:197-200.

- Slack, J., Isaacs, H. and Darlington, B. 1988. Inductive effects of fibroblast growth factor and lithium ion on *Xenopus* blastula ectoderm. *Development* 103:581-590.
- Slack, J., Darlington, G., Gillespie, L., Godsake, S., Isaacs, H. and Paterno, G. 1989. The role of fibroblast growth factor in early *Xenopus* development. *Development Suppl.* pp 141-148.
- Slack, J. and Tannahill, D. 1992. Mechanism of anteroposterior axis specification in vertebrates. Lessons from the amphibians. *Development* 114:285-302.
- Smith, J. 1987. A mesoderm-inducing factor is produced by a *Xenopus* cell line. *Development* 99:3-14.
- Smith, J. and Slack, J. 1983. Dorsalization and neural induction: properties of the organizer in *Xenopus laevis*. *Journal of Embryology and Experimental Morphology* 78:299-317.
- Smith, J., Yaqoob, M. and Symes, K. 1988. Purification, partial characterization and biological effects of the XTC mesoderm-inducing factor. *Development* 103:591-600.
- Smith, J., Cooke, J., Green, J., Howes, G. and Symes, K. 1989. Inducing factors and the control of mesodermal pattern in *Xenopus laevis*. *Development Suppl.* pp 149-159.
- Smith, J., Price, B., Van Nimmen, K. and Huylebroeck, D. 1990. Identification of a potent *Xenopus* mesoderm-inducing factor as a homologue of activin A. *Nature* 345:729-731.
- Smith, J., Price, B., Green, J., Weigel, D. and Herrmann, B. 1991. Expression of a *Xenopus* homolog of *Brachyury* (T) is an immediate-early response to mesoderm induction. *Cell* 67:79-87.
- Stern, C., Hatada, Y., Selleck, M. and Storey, K. 1992. Relationships between mesoderm induction and the embryonic axes in chick and frog embryos. *Development Supplement* pp. 151-156.
- Stewart, R. and Gerhart, J. 1990. The anterior extent of dorsal development of the *Xenopus* embryonic axis depends on the quantity of organizer in the late blastula. *Development* 109:363-372.
- Sudol, M. 1988. Expression of proto-oncogenes in neural tissues. *Brain Research Reviews* 13:391-403.

Mesoderm Induction in *Xenopus*

- Thomsen, G., Woolf, T., Whitman, M., Sokol, S., Vaughan, J., Vale, W. and Melton, D. 1990. Activins are expressed early in *Xenopus* embryogenesis and can induce axial mesoderm and anterior structures. *Cell* 63:485-493.
- van den Eijnden-Van Raaij, A., van Zoelent, E., van Nimmen, K., Koster, C., Snoek, G., Durston, A. and Huylebroeck, D. 1990. Activin-like factor from a *Xenopus laevis* cell line responsible for mesoderm induction. *Nature* 345:732-734.
- Whitman, M. and Melton, D. 1990. Signal transduction during mesoderm induction in *Xenopus*. *Journal of Reproduction and Fertility Supplement* 42:249-254.
- Wilkinson, D., Peters, G., Dickson, C. and McMahon, A. 1988. Expression of the FGF-related proto-oncogene *int-2* during gastrulation and neurulation in the mouse. *The EMBO Journal* 7:691-695.
- Wilkinson, D., Bhatt, S. and Herrmann, B. 1990. Expression pattern of the mouse *T* gene and its role in mesoderm formation. *Nature* 343:657-659.

BOOK REVIEW

Laws, Edward A. (2nd ed.). 1993. AQUATIC POLLUTION, an introductory text. John Wiley & Sons, ISBN 0-471-58883-0, 611 p. Softcover, \$54.95.

This is a college undergraduate textbook, and its stated purpose is to educate both the lay public and policy makers about the scientific aspects of water pollution so that they can make informed decisions about issues related to water pollution. The book is admirably suited to this purpose, and is recommended reading for anyone who wants to know more about what can and should be done, either personally or societally, about various kinds of pollution.

The book is organized as follows. Seventeen chapters cover topics such as Urban Runoff, Plastics in the Sea, and Radioactivity. Each chapter contains a simple explanation of the nature of the problem and most contain one or more case studies. The case studies are discussed in terms of their practical implications and with an eye towards determining what practices are safe/economical under what conditions. I found most of the case studies intensely interesting, and they are one of the best features of the book.

The discussions of various toxins are about as complete as they can be in a book of this scope and length, but in some cases a little more information would be helpful. For example, in the discussion of PCBs, Laws does not mention the controversy in the popular press about whether PCBs are as dangerous to humans as has been reported. Also, he says "PCBs discharged to aquatic systems are presumably either degraded in the water column or buried in the sediments;" apparently unaware of the detailed studies conducted by Sanders (1989) and others, demonstrating that PCBs in the Hudson River are mostly buried in the sediment...and then are remobilized by flood events.

The book has a few other problems of course. There seems to be a little anthropocentrism too, with emphasis on avoiding practices harmful to humans but not those that might harm only wildlife. One of the most irritating things about this book is the high frequency of passive sentence constructions. The book provides insufficient explanation of how some calculations are made; e.g., of toxicity levels used by the EPA. These calculations would probably be explained in more detail in a classroom, but the casual reader does not have this extra assistance.

On the plus side, some topics that have been bandied about in the popular press, such as the methods used to determine whether chemicals are carcinogenic, are clearly explained in relatively few words in this book. The real problems with these studies are rarely mentioned, and probably not understood, by the talking heads who

Review

attack the EPA, FDA, and other governmental organizations on TV and on the radio. Every layperson who reads *Aquatic Pollution* will come away with a much better understanding of why environmental problems are not as easy to solve as one might think.

I only noticed a few factual errors, illustrations are for the most part very easy to interpret and relevant to the text, and I only counted eight typographical errors. Obviously the book was carefully edited. The book is informative, engagingly written, and not all that expensive. I recommend it.

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REFERENCE

Sanders, J. E., 1989, PCB-pollution in the upper Hudson River: from environmental disaster to "environmental gridlock:" Northeastern Environmental Science, v. 8, p. 1-86.

**UNIVERSITY OF ALABAMA AT BIRMINGHAM - SCHOOL OF MEDICINE
29th ANNUAL MEDICAL STUDENT RESEARCH DAY, OCTOBET 19, 1992**

The following abstracts have been submitted by participants in the poster session of the Medical Student Research Day under the sponsorship of Dr. Wayne Finley. In the world of research we are expected not only to discover, but to discuss and defend our work. The Research Day provides a forum for the wide range of clinical and basic research our medical students have done in one summer; the Journal has offered to expand our audience and thus our participation in the world of research. The efforts of several of our students will be published in collaboration with their mentors. The First place prize winner will present his data at the National Students Research Forum in Galveston, Texas.

The finalists were:

1st prize: Howard Masuoka - *A Point Mutation in the Human Globin Locus Enhancer Alters the Expression of a Linked Reporter Gene.*

2nd prize: Brian Hughes - *Targeted Gene Expression in Human Melanoma Cells "In vitro" Using the Tyrosinase Promoter.*

3rd prize: Agnes Cartner - *An Animal Model to Predict the Immunogenicity of Murine V-regions in Man.*

4th prize: Andrea Smith - *Developmental Regulation of "Trypanosoma Brucei" Killing by Human High Density Lipoproteins.*

5th prize: Thomas Evans - *Naphthol- D-Xyloside Restores Tumor Formation in a Heparan Sulfate-Deficient Chinese Hamster Ovary Cell Mutant.*

6th prize: Charles Yang - *Ascorbate Modulates Dompaminergic Agonist Binding.*

Special Awards were presented to:

John E. Irby Award - Michael Callahan - *Acetozolamide Prophylaxis Reduces Systemic Hypertriglyceridemia and Tumor Necrosis.*

Nephrology Research Award - Muthoka Mutinga - *Heightened Sympathetic Response to Cold Pressor Test in Normotensive Blacks.*

NCR Award - Duncan Lill - *99mTc-HM-PAO Brain SPECT Evaluation of Autistic Disorder.*

Charles D. Kochakian Award - Christi Klein - *Determination of the Effects of FSH and TNF-Alpha on Aromatase Cytochrome P450 mRNA in Rat Granulosa Cells Using Polymerase Chain Reaction (PCR) Amplification.*

AMA/ERF Award - Jacinda Sampson - *Purification of the gp70 Subunit of the Mason-Pfizer Monkey Virus.*

ABSTRACTS

CORONARY REACTIVE HYPEREMIA AND MYOCARDIAL STUNNING. V. S. Reddy, J. W. Kirklin MD, E. H. Blackstone MD, S. B. Digerness PhD, Division of Cardiovascular Surgical Research, University of Alabama School of Medicine, Birmingham, Alabama 35294

Cardiovascular surgery is one method used to treat a variety of heart diseases. An important issue associated with this intervention is myocardial management and preservation. We are presently conducting a series of pig studies to understand more completely the phenomena that follow global and regional myocardial ischemia. Three month old pigs are placed on cardiopulmonary bypass (with their coronary circulation completely isolated) and instrumented in order to measure continuously their coronary flow, arterial-venous oxygen difference and myocardial oxygen consumption (MVO_2). Blood samples are used to measure pH, pCO_2 , pO_2 , Hb and oxygen saturation. The experimental protocol consists of exposing the pigs to periods of normothermic, global myocardial ischemia followed by either normokalemic or hyperkalemic sanguinous reperfusion. Ischemic times are 0, 11.25, 22.5 and 45 minutes followed by 30 minutes of constant pressure (60 mmHg) aortic root reperfusion.

Initial findings in the hyperkalemic reperfusion group show a sharply increased level of coronary flow and MVO_2 during the early phase of reperfusion for all periods of ischemia (except O' ischemia). It is our hypothesis that repletion of ischemically depleted ATP and CrP is responsible for the observed increase in MVO_2 . We further hypothesize that this increase in MVO_2 represents the presence of a heterogenous population of myocytes consisting of dead myocytes, recovered myocytes, myocytes recovering with no mechanical activity and myocytes recovering with mechanical activity and an elevated MVO_2 . This latter group of myocytes has been called stunned myocytes.

VARIATIONS WITHIN THE ATTACHMENT PROTEIN OF RESPIRATORY
SYNCYTIAL VIRUSES: RELEVANCE TO VACCINE DESIGN. M. Colvin,
University of Alabama School of Medicine; W. Sullender, M.D. Department of
Pediatrics, Children's Hospital, Birmingham, AL

Human respiratory syncytial virus is the major cause of pneumonia and bronchiolitis in children. There is at present no effective vaccine against the virus. Antigenic differences among respiratory syncytial viruses may play a role in the ability of these viruses to escape the immune system, as evidenced by infections occurring in the presence of maternal antibody and the fact that reinfections occur throughout life. Human respiratory syncytial virus has two major antigenic subgroups, A and B. In recent work, it has been shown that variation exists within each subgroup with the greatest variation found in the ectodomain of the attachment protein G. In this preliminary study, we analyzed a pair of subgroup A RS virus strains WV19983 and WV23836 which were isolated in 1987 and 1988 from a child who had repeat infections. The G protein ectodomains of these isolates were cloned and sequenced or sequenced directly, and their partial sequences were analyzed for variations in nucleotide and amino acid sequence. When compared to a subgroup A prototype virus (A2), WV19983 showed 94% amino acid identity and WV 23836 showed 86% identity. When WV19983 and WV23836 were compared to each other, they showed 82% identity. From 32% to 50% of the nucleotide changes among these genes resulted in amino acid changes. This finding is suggestive of selective pressure for change, which may be due to the host immune response. In summary, these data show an 18% difference in the partial amino acid sequences of the attachment protein G of viruses isolated from repeat infections of a child. These data support the fact that variation exists in the G gene within subgroups and that these variations lead to substantial changes in amino acid sequences. These variations in amino acid sequence may help to explain reinfections, and understanding the extent and location of these variations may aid in the design of a vaccine.

DEVELOPMENTAL REGULATION OF TRYPANOSOMA BRUCEI KILLING
BY HUMAN HIGH DENSITY LIPOPROTEINS. Andrea Smith and Stephen
Hajduk, Dept. of Biochemistry, UAB, Birmingham, AL 35294

African trypanosomes cause both human and bovine diseases in large regions of Africa. The host range of the bovine parasite, Trypanosoma brucei brucei, is restricted due to its sensitivity to normal human serum. Studies have shown that a subclass of human high density lipoproteins (HDLs) contains a specific trypanosome lytic factor (TLF) which will kill Trypanosoma brucei but not Trypanosoma rhodesiense or Trypanosoma gambiense. Sensitivity to TLF changes during the developmental cycle, the bloodstream form being sensitive while the insect developmental stage, the procyclic form, is resistant. I have examined this differentiation process to see what other changes were occurring which might influence TLF sensitivity. Optimal conditions were established for differentiation. This was found to be when the trypanosome cell number was at 5×10^7 to 1×10^{10} /ml of blood in a 3 to 4 day mouse infection. Differentiation required a temperature drop from 37 to 26 C. TLF sensitivity, rate of protein synthesis, cell number, and presence of the variable surface protein (VSG) coat were monitored throughout the differentiation process. Protein synthesis decreased about 3 fold in one hour but returned to normal in 4 to 24 hours. TLF sensitivity was lost in 8 to 16 hours and the VSG coat was lost in approximately 32 hours. Cell number began to increase after 24 hours. Differentiation to the procyclic form appears complete within 24 to 48 hours. Since protein synthesis inhibition occurs prior to the loss of TLF sensitivity, it may be involved in the resistance to TLF.

PURIFICATION OF THE GP70 SUBUNIT OF THE MASON-PFIZER MONKEY VIRUS. Jacinda Sampson, Susan Roberts and Eric Hunter, Dept. of Microbiology, UAB, Birmingham, AL 35294

The Mason-Pfizer monkey virus is a type D retrovirus, capable of infecting both the B and T cells of its host, causing a global immunosuppression. In the study of viral structure and life cycle, a source of the purified glycoprotein in its native glycosylation and folding states is useful. It facilitates the production of monoclonal antibodies for use in a range of assays, or it can be used directly for screening libraries for the viral receptor.

A mutant form of the glycoprotein engineered by Dr. Brian Brody into a pSHRM vector was transfected into HeLa cells. Lacking eleven amino acids downstream of its cleavage site, the plasmid encodes a form of the Pr86 precursor that is properly synthesized, glycosylated and cleaved. The gp70 cleavage product is shed into the culture supernatent. (Brody and Hunter, 1992)

Sequential precipitation of the collected supernatents at 40% and 100% ammonium sulfate first partially purified and concentrated the gp70. The resuspended protein was desalted by gel filtration chromatography. It was further purified on a lentil lectin affinity column. The resultant eluent was concentrated and portions were labeled by fluoresceination and biotinylation. Preliminary results by ECL show binding of the biotinylated gp70 and its proteolytic fragments to HeLa cells at higher levels than biotinylated BSA. A FACS analysis of binding revealed higher binding of FITC labeled gp70 to HeLa cells than to MPMV-infected HeLa cells, which have been previously shown to down regulate their viral receptors. These labeled products will be used as probes for identification of the MPMV receptor.

CT, MRI, AND r-CBF SPECT FINDINGS IN AUTISTIC DISORDER. Duncan W. Lill and James M. Mountz, Division of Nuclear Medicine, Department of Radiology; Leland C. Tolbert, Department of Psychiatry, University of Alabama School of Medicine, Birmingham, Alabama, 35233.

We report a unique methodology and preliminary results of a study utilizing the regional cerebral blood flow (r-CBF) tracer ^{99m}Tc -Hexamethyl-propyleneamine oxime (HMPAO) and brain single photon emission computed tomography (SPECT) of four severely autistic subjects. Subtle anatomical abnormalities have been reported from CT or MRI studies and post mortem examination. Neuroimaging using either positron emission tomography (PET) or SPECT have the potential of detecting *in vivo* cerebral activity changes, but require the subject to remain still (without sedation) during scanning. High resolution SPECT was performed while the subjects were under general anesthesia. Because HMPAO is rapidly extracted and fixed in the brain 10 minutes post-injection, the scans reflected the subjects' r-CBF while in their usual alert behavioral state. Autistic Behavior Checklist scores for the four subjects were 90, 71, 66, and 85. Average counts/pixel were analyzed by the asymmetry index ($A.I. = R-L_0/(R+L)/2$) for cerebral cortical regions, basal ganglia, and cerebellum. Values were considered abnormal if the $A.I.$ was > 2 s.d. from age matched normals. Results showed decreased r-CBF involving the right temporal lobe in all subjects (-19.6,-16.1,-11.1,-19.7% respectively), and this decrease correlated with the symptom severity. This study highlights the advantages of using high resolution HMPAO r-CBF brain SPECT and general anesthesia in severely non-compliant subjects by capitalizing on the non-redistributive properties of HMPAO. In conclusion, these findings suggest that right temporal lobe dysfunction is a causative factor in Autistic Disorder.

THE POTENTIAL ROLE OF KERATAN SULFATE PROTEOGLYCAN IN ALZHEIMER'S DISEASE. Omar K. Danner, Dept. of Cell Biology, University of Alabama, Birmingham, Alabama 35294

A CNS-specific keratan sulfate proteoglycan (KSPG) was recently identified in our laboratory. Preliminary data indicated that this KSPG is related to the neuronal pathology associated with Alzheimer's disease (AD), and that it is also associated with the early phases of senile plaque formation.

The association of our KSPG with the early phases of plaque formation suggested that the proteoglycan may be involved in amyloid deposition. One of the current hypotheses indicates that a proteoglycan is responsible for this deposition of amyloid. Since our proteoglycan is associated with the early phases of AD, we hypothesized that the KSPG is capable of interacting with the amyloid peptide. The KSPG was isolated from both human and rat brains. The mAb TED15, which recognized the proteoglycan, was used to detect the keratan sulfate proteoglycan. ELISA methods were used to test binding to beta-amyloid and a reverse sequence peptide. Preliminary data suggest that the rat KSPG may specifically bind β -amyloid relative to reverse sequence peptide. Further investigation will be necessary to confirm the interactions of the KSPG with the amyloid peptide.

EFFECTS OF FOLLICLE STIMULATING HORMONE (FSH) AND TUMOR NECROSIS FACTOR ALPHA (TNF α) ON AROMATASE mRNA IN RAT GRANULOSA CELLS DETERMINED USING POLYMERASE CHAIN REACTION (PCR) AMPLIFICATION. CM Klein, BA Conway-Myers, CR Parker, Jr., MP Steinkampf. Department of OB/GYN, University of Alabama at Birmingham, Alabama 35233-7333

The regulation of follicular recruitment and atresia is thought to occur through the coordinated actions of steroid and polypeptide hormones. The purpose of our study was to determine the effect of FSH and TNF α on estrogen production and mRNA levels for aromatase cytochrome P450 (P450AROM), the enzyme that regulates the conversion of C19 steroids to estrogens, on granulosa cells from follicles of differing sizes. Rat ovarian follicles were size-sorted [small (<200 μ m), medium (200-400 μ m), and large (>400 μ m)] by filtration with graduated Teflon sieves. Granulosa cells were then harvested and cultured (10^8 cells/well) for 48 hours in serum-free medium in the presence or absence of FSH (20 ng/ml), TNF α (1 ng/ml) or a combination of the two. P450AROM mRNA levels in cultured cells were assessed by isolation of RNA followed by reverse transcription with a 3'-oligonucleotide specific for the P450AROM mRNA. The cDNA was then amplified using PCR with primers specific for the P450AROM, and the PCR product was electrophoresed on a polyacrylamide gel and silver-stained for analysis. Aromatase activity was estimated by the conversion of [H^3]-androstenedione to estrone and estradiol using column chromatography. Aromatase activity and P450AROM mRNA levels were increased with FSH treatment but were decreased with TNF α treatment compared to untreated cells. TNF α also inhibited the FSH-stimulated increase in aromatase activity and P450AROM mRNA levels. Granulosa cells from 200-400 μ m diameter follicles showed the greatest changes in aromatase activity and P450AROM mRNA levels with FSH and/or TNF α treatment. We conclude that FSH and TNF α exert their effects on follicular development and estrogen production primarily in medium-sized follicles.

Notes

Notes

INSTRUCTIONS TO AUTHORS

Editorial Policy: Publication of the *Journal of the Alabama Academy of Science* is restricted to members. Membership application forms can be obtained from Dr. Larry R. Boots, Department of Obstetrics & Gynecology, University of Alabama, Birmingham, AL 35294. Subject matter should address original research in one of the discipline sections of the Academy: Biological Sciences; Chemistry; Geology; Forestry, Geography, Conservation, and Planning; Physics and Mathematics; Industry and Economics; Science Education; Social Sciences; Health Sciences; Engineering and Computer Science; and Anthropology. Timely review articles of exceptional quality and general readership interest will also be considered. Invited articles dealing with Science Activities in Alabama are occasionally published. Book reviews of Alabama authors are also solicited. Submission of an article for publication in the *Journal* implies that it has not been published previously and that it is not currently being considered for publication elsewhere.

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Special Issue

HEALTHY ALABAMA YEAR 2000



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HEALTHY PEOPLE 2000

NATIONAL HEALTH PROMOTION AND DISEASE PREVENTION OBJECTIVES¹

Lynn M. Artz, MD, MPH
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INTRODUCTION

Healthy People 2000 is a national initiative to improve the health of all Americans through prevention. The cornerstone of this effort is a set of national health promotion and disease prevention goals and objectives for the year 2000. Coordinated by the U.S. Public Health Service of the Department of Health and Human Services, Healthy People 2000 is an unprecedented collaboration of public and private sector groups committed to making prevention a national priority.

The Need

Many Americans are robbed of years of precious life. Our Nation is also heavily burdened by chronic illnesses and disabling conditions that diminish the quality of our lives. More than 60 percent of Americans die before age 65--and 20 percent of our days are spent disabled, injured, or ill. Premature deaths and chronic conditions carry a heavy toll in economic terms as well as human terms. The costs of medical care and lost productivity from our leading health problems runs to hundreds of billions.

We have the potential to achieve dramatic health improvements in this country. But to do so, we must make prevention a higher priority. Research has identified behavioral and environmental risk factors for our major health problems and we have learned how to reduce our risks. Numerous preventive interventions have been developed and demonstrated effective. If applied broadly, these measures could eliminate nearly half of cardiovascular deaths and one-fourth of cancer deaths. It is estimated that 40 to 70 percent of premature deaths are preventable as is one-third to two-thirds of disability (13). The case for prevention is compelling. Yet of the half-trillion dollars spent for health care each year, more than 95 percent goes to treat rather than prevent illness and injury.

¹Manuscript received 6 December 1993; accepted 13 December 1993.

THE ORIGINS OF HEALTHY PEOPLE 2000

To make prevention a higher national priority, we have developed a national prevention agenda for the 1990s framed as goals and objectives: Healthy People 2000. This effort builds on an earlier set of goals and objectives that was initiated in 1979 (25,26). Despite progress in the 1980s, a nationwide commitment to disease prevention and health promotion remains to be achieved.

Planning for Healthy People 2000 began in 1987. A consortium of nearly 300 national organizations was convened to help guide the process. Consortium members included professional organizations (e.g., American Dietetic Association, American Public Health Association, American Academy of Family Physicians), voluntary health organizations (e.g., American Lung Association, March of Dimes), other voluntary organizations (e.g., American Association of Retired Persons, Girl Scouts of the U.S.A.), trade associations (e.g., Produce Marketing Association, Group Health Association of America), and education institution associations (e.g., Association of American Medical Colleges, American Association of Colleges of Nursing). All State and territorial health departments were also members of the Consortium and active partners in the development of Healthy People 2000.

Considerable effort was made to obtain public and professional input throughout the 3-year development process. Twenty-five public hearings were held across the country to solicit input. Then work groups were formed to draft new objectives. Draft objectives were widely circulated for review and revised. Thousands of individuals, agencies, and organizations participated in some way to craft the year 2000 objectives that are the cornerstone of Healthy People 2000.

Several important criteria guided the year 2000 objectives development. The objectives were to be scientifically sound, to address the issues of greatest priority, to be quantified and measurable, and to be attainable. Attainability was a key criteria. The year 2000 objectives were to be challenging yet attainable targets, not commendable but unrealistic aspirations. Quantification and measurability were also key. For in addition to providing direction, the objectives would serve as a yardstick for measuring progress.

In 1990, the year 2000 goals and objectives were published (27) and released to the Nation at a national conference. The Nation had a new set of health objectives--300 in all--and 3 broad overarching health goals. Although published in a government document, the objectives are not a Federal plan. They are national in scope and it will take a national effort to achieve them.

HEALTHY PEOPLE 2000: THE VISION

Healthy People 2000 is a statement of national opportunities. It is a vision of the future that challenges our Nation to strive for that which is within our grasp to

National Health Promotion and Disease Prevention Objectives

achieve. Healthy People 2000 is a vision outlined through goals and objectives. It is a vision that can be achieved with national effort.

The three overarching goals of Healthy People 2000 are to: increase the span of healthy life for Americans, reduce health disparities among Americans, and achieve access to preventive services for all Americans (see Table 1).

Table 1: Healthy People 2000 Goals

- Increase the span of healthy life for Americans
- Reduce health disparities among Americans
- Achieve access to preventive services for all Americans

The 300 objectives, the heart and soul of Healthy People 2000, are grouped into 22 priority areas for intervention (see Table 2). The objectives target improvements in health status, risk reduction, and services and protection. There are also sub-objectives for populations that experience higher rates of illness and injury--special population targets for racial and ethnic minorities, children, adolescents, older people, and people with disabilities.

Table 2: Healthy People 2000 Priority Areas

Health Promotion

1. Physical Activity and Fitness
2. Nutrition
3. Tobacco
4. Alcohol and Other Drugs
5. Family Planning
6. Mental Health and Mental Disorders
7. Educational and Community-Based Programs

Health Protection

9. Unintentional Injuries
10. Occupational Safety and Health
11. Environmental Health
12. Food and Drug Safety
13. Oral Health

Preventive Services

14. Maternal and Child Health
15. Heart Disease and Stroke
16. Cancer
17. Diabetes and Chronic Disabling Conditions
18. HIV Infection
19. Sexually Transmitted Diseases
20. Immunizations and Infectious Diseases
21. Clinical Preventive Services

Surveillance and Data Systems

22. Surveillance and Data Systems

It is difficult to summarize the goals and objectives of Healthy People 2000 in their entirety. Healthy People 2000--with its 3 broad goals, 22 priority areas for intervention, and 300 specific, measurable objectives--is a complex initiative which challenges us in many ways. The three goals challenge us in a broad sense. However, it is the 300 quantified and measurable objectives that best define the opportunities we have for improving services, reducing risks, and improving health outcomes. Furthermore, the objectives challenge us to attain these improvements--or be held accountable for our failure to do so.

The Maternal and Infant Health objectives, for example, challenge us to reduce infant mortality from a rate of 10 to 7 deaths per 1000 live births and to reduce maternal mortality by half. To achieve these health improvements, the Maternal and Infant Health objectives challenge us to reduce risks such as low birth weight and to improve services such as increasing first trimester prenatal care. Thus the objectives present specific challenges--and also offer a blueprint for action. They identify important desired endpoints and in broad strokes begin to outline ways to achieve them.

In some cases, the challenges posed by the objectives are new. In other cases, the objectives challenge us to persist and intensify our efforts where success has been elusive to date. Even where we have been successful, Healthy People 2000 urges us on to greater gains. For example, the death rate for coronary heart disease has declined by 40 percent over the past fifteen years. The stroke death rate has declined by 53 percent. While we celebrate these declines, the year 2000 objectives challenge us to reduce coronary heart disease and stroke mortality by another 25 percent and 35 percent respectively. Similarly, despite a steady decline in cigarette smoking prevalence, the year 2000 objectives challenge us to intensify our efforts in this area

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as well. Rather than accept a smoking prevalence among adults of 22 percent in the year 2000 (the projected prevalence based on current trends), we set as our challenge a prevalence of 15 percent.

In reviewing the objectives as a whole, several themes emerge. First, while the objectives challenge us to reduce premature mortality, they also challenge us to reduce illness, injury, and disability--and to improve quality of life.

Second, in keeping with the second goal to reduce disparities, the objectives challenge us to target our attention and resources towards those populations experiencing health problems with greater frequency or severity. More than 40 specific targets have been set for improving the health of Black Americans, for example, and 25 targets each have been set for Hispanic Americans and American Indians and Alaska Natives. These special population targets highlight the profound disparities that exist and challenge us to address these disparities, not hide them behind population averages.

Third, although the objectives acknowledge the important role that behavior plays in determining health and illness, the objectives also acknowledge the contribution of the larger physical, social, and cultural environment. Multiple objectives challenge us to create safer roadways and housing and to reduce hazardous occupational and environmental exposures. They also challenge us to create physical and social environments that promote and support healthier lifestyles.

The objectives also acknowledge the importance of clinical preventive services in promoting health and preventing disease. Numerous objectives seek to increase the use of screening tests, counseling interventions, and immunizations. Several objectives specifically address barriers that impede access to and use of clinical preventive services. One objective challenges us to increase to at least 95 percent the proportion of people who have a specific source of primary care for coordination of their preventive and episodic health care. Another objective challenges us to improve financing and delivery of clinical preventive services so that virtually no American has a financial barrier to essential preventive services.

Fourth, the objectives challenge us to be varied and creative in our approaches. The objectives encourage educational, behavioral, environmental, policy, and legislative approaches. The objectives also challenge us to improve our surveillance systems.

Finally, the objectives are intended to serve as a challenge to all sectors of American society. Government at all levels--Federal, state, and local--has an important role to play. Several objectives acknowledge the leadership role of state and local health departments. A number of objectives challenge communities to increase the availability and accessibility of fitness trails and facilities, community-wide health promotion and disease prevention programs, and healthy community environments.

At least 14 objectives specifically challenge employers to ensure safe work environments and to offer worksite health promotion and disease prevention activities. More than 18 objectives challenge primary care providers to incorporate more preventive services into their practice.

About 12 objectives specifically challenge schools to provide students with nutrition education and healthy school meal services, frequent, high-quality physical education, and age-appropriate instruction to prevent injuries, STD and HIV infections, and tobacco, alcohol, and other drug use. Two other objectives that address preschool education and high school graduation rates acknowledge the relationship of school achievement to good health--and the importance of intersectoral collaboration.

NATIONAL ACTION

Establishing objectives is only the first step. Action must be taken to attain them. Current prevention efforts must be intensified and new efforts must be initiated to accelerate progress where progress is needed. Though much remains to be done, considerable activity is already underway.

Public Health Service Action

U.S. Public Health Service (PHS) agencies in the Department of Health and Human Services (DHHS) coordinate the Federal government's activities in support of Healthy People 2000. PHS agencies such as the Centers for Disease Control and Prevention (CDC) and the National Institutes for Health (NIH) serve as lead agencies for each of the 22 priority areas. The Office of Disease Prevention and Health Promotion (ODPHP) is responsible for overall coordination of the initiative.

Lead PHS agencies do not work alone to achieve the objectives for any one priority area. Through interagency workgroups, lead agencies work together with other PHS agencies, other DHHS agencies (e.g., Health Care Financing Administration), and other Departments (e.g., Environmental Protection Agency and Departments of Agriculture, Education, Labor, and Transportation). Collaboration with private sector groups occurs as well.

The activities of the PHS agencies and their partners to achieve the objectives are numerous and diverse. Relevant programs of the eight PHS agencies and their plans for accomplishing the year 2000 objectives were outlined in the 1992 publication titled *Healthy People 2000: Public Health Service Action* (29). For example, the Agency for Health Care Policy and Research (AHCPR) has established new SBIR (Small Business Innovation Research) funding to stimulate the development of information systems to foster achievement of Healthy People 2000 objectives. Similarly, physical

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activity objective 1.12 provided the impetus for CDC's National Center for Chronic Disease Prevention and Health Promotion to fund a project to develop the protocols needed by physicians to assess and counsel patients about exercise, and to begin training physicians to use these protocols.

The Assistant Secretary for Health monitors the implementation of plans to meet the objectives through regularly scheduled progress reviews. At each review, the focus is on one priority area. The PHS agency with lead responsibility for the priority area presents the review, with assistance from members of the interagency workgroup for that priority area and representatives of invited State agencies and private organizations. Each review addresses the following questions: a) What is the PHS strategy for achieving the priority areas's objectives, b) Are PHS resources being used effectively, c) Have linkages been made with other Federal partners, d) Are key private sector organizations collaborating on implementation, e) What barriers could stand in the way of achieving the targets, and f) What strategies are being pursued to overcome the barriers? As part of the review, current data for the objectives for the priority area are compared with the baseline data and the year 2000 targets.

The first reviews have been completed for all 22 priority areas. Several cross-cutting reviews (e.g., reviews of the objectives for American Indians and Alaska Natives, women, and Hispanic Americans) have also been conducted and more are planned. One-page summaries of the progress reviews are published as *Healthy People 2000 PHS Progress Reports* by the Office of Disease Prevention and Health Promotion.

The Office of Disease Prevention and Health Promotion (ODPHP) coordinates DHHS policy and program development in disease prevention and health promotion. ODPHP is the office responsible for the overall coordination of Healthy People 2000 including development, monitoring, and assuring that public and private sector programs to achieve the objectives are put in place. Through ODPHP's National Health Information Center, ODPHP is the source of valuable information about health promotion in general and Healthy People 2000 in particular. A current publication list can be obtained from the National Health Information Center by calling (800) 336-4797 or (301) 565-4167. Callers may ask to be put on the mailing list for ODPHP's newsletter, *Prevention Report*, and *Healthy People 2000 UPDATE*, a two-page supplement to *Prevention Report*. Recipients of *Prevention Report* also receive the *PHS Progress Reports* mentioned above.

ODPHP has funded several cooperative agreements to stimulate programs to achieve the objectives for populations at increased risk (e.g., older adults, racial and ethnic minorities). Organizations such as the National Medical Association, the National Coalition of Hispanic Health and Human Services Organizations (COSSMHO), the Asian American Health Forum, and the American Indian Health Care Association received multi-year funding to develop programs to achieve the

special population targets for Black Americans, Hispanic Americans, Asian Americans and Pacific Islanders, and American Indians and Alaska Natives respectively. Several innovative programs and helpful materials were created as a result. The *Promoting Healthy Traditions Workbook* is one example (3).

ODPHP has also funded several cooperative agreements to catalyze prevention activities in important settings (e.g., worksites, communities). The Washington Business Group on Health received funding to establish The National Resource Center on Worksite Health Promotion. This Resource Center maintains a computerized database of successful and innovative worksite health promotion programs and has produced a series of publications including *Healthy People 2000 at Work: Strategies for Employers* (21-24). Similarly, the National Civic League received funding to stimulate healthy community projects. Through the Healthy Communities Action Project, the National Civic League has conducted training workshops for community representatives. They have also published the *Healthy Communities Directory* (18), *Healthy Communities Handbook* (19), and *Healthy Communities Resource Guide* (20).

The Centers for Disease Control and Prevention (CDC), through the National Center for Health Statistics (NCHS) is the lead agency for the Data and Surveillance priority area. Early in the decade, NCHS convened Committee 22.1 to establish a set of health status indicators (Objective 22.1) for use at all levels of government. NCHS has also awarded 5-year grants to seven states to enhance their capacity to assess progress toward Healthy People 2000 objectives. NCHS will play a crucial role in tracking national progress toward the year 2000 objectives throughout the decade. The National Health Interview Survey (NHIS) has been redesigned to track many of the objectives. Official tracking data for Healthy People 2000 will be published annually in *Health, United States*.

Congressional Action

Congress has incorporated Healthy People 2000 into national legislation. In 1989, Federal Title V legislation mandated the incorporation of program activities and plans related to Healthy People 2000 in State Title V fiscal year 1991 Maternal and Child Health Services Block Grant Applications.

With the 1992 authorization of the Preventive Health and Health Services Block Grant program, Congress again linked State grant-funded activities to the year 2000 objectives. Each state must have a plan specifying the populations to be served by the activities and programs. Each state also must agree to measure progress in improving the health status of the population and to develop sets of data for uniformly defining health status for tracking the year 2000 health objectives.

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The Indian Health Care Improvement Act (Public Law 102-583) also links the allocation of resources to Healthy People 2000 objectives. This law creates an annual reporting requirement for the Indian Health Service to inform Congress of the health status of American Indians and Alaska Natives.

Consortium Action

The Healthy People 2000 Consortium has grown to more than 375 members and continues to meet annually. The activities undertaken by Consortium members to support Healthy People 2000 are numerous and diverse. Nearly all Consortium members have publicized the objectives to their members. Many have highlighted the objectives and ways to achieve them at annual meetings. Some have developed new programs and materials to reflect a new emphasis on achieving national health objectives. Some of the many activities undertaken by Consortium members to support attainment of Healthy People 2000 objectives were summarized in the 1992 publication *Healthy People 2000: Consortium Action* (28). A Healthy People 2000 Consortium database is currently being developed by ODPHP to facilitate information sharing between Consortium members regarding prevention activities.

Here are just a few examples of consortium member activities. The American Public Health Association (APHA) made the year 2000 objectives the theme for their 1990 annual meeting. The Association of State and Territorial Health Officials (ASTHO) sponsored the National Health Objectives Act to increase funding for states to pursue national and state health objectives. The American Hospital Association (AHA) published and distributed to all member hospitals a kit titled *Healthy People 2000: America's Hospitals Respond* (2). The American Association of School Administrators (AASA) published and distributed 19,000 copies of *Healthy Kids 2000: An Action Plan for Schools* (1).

Wellness Councils of America (WELCOA) adopted the Healthy People 2000 worksite objectives as their organization's agenda for the decade. An early activity was to publish *Healthy People 2000 at the Worksite* (31) which has been distributed to more than 5,000 business leaders and interested others. In 1991, WELCOA launched WELL CITY USA, a joint project with United Way of America.

To help achieve the nutrition objectives for children and schools, the American School Food Service Association (ASFSA) developed an in-service training program for ASFSA members. Titled *Healthy E.D.G.E. in Schools: Eating, Dietary Guidelines, and Education*, this program consists of a motivational videotape and a companion "how-to" booklet (6). Several supplements, a participant's manual, and a train-the-trainer course and materials have also been developed. In 1995, Healthy E.D.G.E. training will be required for school food service worker certification.

The American College of Sports Medicine (ACSM) established a Healthy People 2000 committee to develop a multi-year program for the objectives. Hundreds of members have signed on as volunteer leaders for their states and communities. Volunteer and committee activities are reported in a regular column in ACSM's quarterly magazine (7-10). ACSM's Healthy People 2000 committee recently reorganized into an executive committee and five subcommittees: a) Primary Care Providers, b) Pediatric Fitness and Schools, c) Worksite, d) Public/Community Health, and e) ACSM Healthy People 2000 Awards. In 1993, the ACSM Foundation Board of Directors designated funding in amounts up to \$5000 per project for grassroots projects promoting the Healthy People 2000 physical activity objectives. As many as three 1-year projects per regional chapter will be funded in June of 1994.

In 1991, following a challenge by former Surgeon General Antonia Novella in her keynote address at their annual meeting, the National Association of Children's Hospitals and Related Institutions (NACRI) formally resolved to embark on a campaign toward achieving the Healthy People 2000 objectives for infants, children, and adolescents. Focusing on immunizations in 1991 and injury prevention in 1992, the Association now sponsors an annual initiative in support of Healthy People 2000.

State Action

Most state health agencies have embraced the concept of health objectives. By December of 1991, 21 states (including Alabama) had developed state-specific health objectives. By December of 1993, 30 states had finalized state health objectives. Many states have formed state-wide coalitions and consortia to facilitate attainment of their objectives. Some states with published objectives have published implementation plans. A few have published first progress reports.

In 1991, the Public Health Foundation compiled information about state objective setting activities. This information was summarized in *Healthy People 2000: State Action* (30). At the time of the survey, nearly all states and territories were working to develop state health objectives. Most indicated that their state objectives would guide program development, data collection activities, grant activities, legislative action, and budget-setting processes within the state health agency.

Community Action

Cities, counties, and communities are increasingly engaged in community-wide efforts to promote health and prevent disease. The approaches vary greatly from community to community. Some emphasize consensus-building, partnerships, and coalitions. Some involve extensive grass-roots organizing. Some apply social marketing principles. Others apply rational planning models and feature quantitative assessments, measurable objectives, and periodic evaluations of progress. Some have found the Healthy People 2000 framework helpful (e.g., Chico, California).

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Several resources are available to assist communities with community health promotion efforts. These include *Healthy Communities 2000: Model Standards* (4) and a *Guide to Implementing Model Standards* (5) as well as the Healthy Communities materials developed by the National Civic League (18-20). Cities participating in the California Healthy Cities Project provide excellent models. The approaches and materials of the community heart disease prevention projects (e.g., Stanford, Pawtucket) can be helpful. CDC's PATCH (Planned Approach to Community Health) program materials may also be useful.

Individual Action

Healthy People 2000 has inspired many individual efforts. A few examples from academic settings are offered to convey a sense of the enthusiasm that Healthy People 2000 has generated. For example, Thomas MacFayden and a colleague developed a computer-assisted instruction program to teach medical students about the objectives and their role in achieving them. Julie Doidge analyzed the contents of several popular college health textbooks for their congruence with the national health objectives.

Faculty at the University of Alabama at Birmingham have been particularly enthusiastic about Healthy People 2000. One faculty member provided the impetus for the series of articles that appear in this journal. Another spearheaded the conference and formation of the state-wide coalition described in one of the articles. Another faculty member has required graduate students in Public Health to review articles that introduce Healthy People 2000 and pertinent objectives to select professional audiences (12,14). Students then write similar journal articles for other professional groups (15). Most impressively, at the suggestion of Kathleen Brown and colleagues, the School of Nursing at the University of Alabama at Birmingham has recently revised its graduate level community health nursing curriculum based on the priority areas and health objectives in Healthy People 2000 (11).

NATIONAL PROGRESS

Progress toward the Healthy People 2000 objectives was recently reviewed in *Health, United States, 1992 and Healthy People 2000 Review* (16). As of 1992, 3 percent of the year 2000 objectives had been met and progress had been made toward another 28 percent. Three percent of the objectives showed no change and 4 percent (with multiple targets) showed changes that were mixed. Trends were in the wrong direction for 15 percent of the objectives. Twenty-eight percent of the objectives had no new data with which to evaluate progress. Ten percent of the objectives had new baselines where baselines did not originally exist. Baselines had yet to be obtained for 10 percent.

The priority areas showing the most progress were Heart Disease and Stroke (with progress for 9 of 17 objectives), Unintentional Injuries (with progress for 11 of

22 objectives including 3 objectives that had met or exceeded their targets), and Alcohol and Other Drugs (with progress for 9 of 19 objectives including 1 objective that had exceeded its target).

The priority areas showing the most movement away from the targets were Maternal and Infant Health (with 5 of 16 objectives in this category) and Diabetes and Chronic Disabling Conditions (with 6 of 20 objectives in this category).

A total of 92 objectives had no new data since baselines were published in *Healthy People 2000*. The priority areas with more than half of their objectives in this category were Family Planning (with 6 of 11 objectives) and Oral Health (with 9 of 16 objectives).

The *Healthy People 2000 Review* (16) described above also lists the revised baselines for Healthy People 2000. Baseline rates for some of the objectives were updated to reflect 1990 Census figures, the inclusion of all American Indians and Alaska natives (not just those living in states with reservations), and a change in the method for classifying the race of infants. The revised baselines for Healthy People 2000 can also be found in *Statistical Notes* (17).

HEALTHY PEOPLE 2000 RESOURCES

Healthy People 2000: National Health Promotion and Disease Prevention Objectives--the Full Report and/or the Summary Report--can be ordered from the U.S. Government Printing Office by calling (202) 783-3238. Both documents contain a brief review of the state of the Nation's health, the three goals, and a list of the 300 objectives. The Full Report also contains valuable commentary, trend graphs, data source information, and references. In the Full Report, an entire chapter is devoted to each of the 22 priority areas (e.g., Physical Activity and Fitness, Nutrition). The Full Report also lists personnel needs, surveillance needs, and research needs for each priority area and includes additional appendices.

A *Healthy People 2000 Publications List and Order Form* can be obtained from ODPHP's National Health Information Center by calling (800) 336-4797 or (301) 565-4167. The Summary Report, the 3-volume *Healthy People 2000 Action Series*, and *Healthy People 2000 Priority Area Resource Lists* are among the publications available through ODPHP's National Health Information Center. Information specialists at the National Information Center can also provide source information for Healthy People 2000 materials developed by cooperative agreement recipients (e.g., the National Civic League's *Healthy Communities Directory*) or Consortium members (e.g., WELCOA's *Healthy People 2000 at the Worksite*). Finally, callers may ask to be put on the mailing list for ODPHP's newsletter, *Prevention Report*, and *Healthy People 2000 UPDATE*, a two-page supplement to *Prevention Report*.

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ODPHP's Healthy People 2000 Coordinator can be reached by calling (202) 205-8583 or by writing to the Office of Disease Prevention and Health Promotion, 330 C Street SW, Room 2132, Washington, DC 20201. Up-to-date lists of work group coordinators, state contracts, and Consortium contacts may be obtained from the Healthy People 2000 Coordinator.

CONCLUSION

Every American has a role to play in helping to achieve the goals and objectives set forth in *Healthy People 2000*. Each of us must define that role for ourselves given the arenas in which we function. Some can contribute as professionals. All can contribute as individuals, family members, community residents, and U.S. citizens. Each of us must do our part. To paraphrase the conclusion of the first Healthy People . . . If the commitment is made at every level, we can attain our goals and objectives and Americans who might otherwise have suffered disease and disability will instead be healthy people.

LITERATURE CITED

1. American Association of School Administrators. (1990). *Healthy Kids for the Year 2000: An Action Plan for Schools*. Arlington, VA: American Association of School Administrators.
2. American Hospital Association. (1990). *Healthy People 2000: America's Hospitals Respond*. Chicago, IL: American Hospital Association.
3. American Indian Health Care Association. (1990). *Promoting Healthy Traditions Workbook: A Guide to the Healthy People 2000 Campaign*. St. Paul, MN: American Indian Health Care Association.
4. American Public Health Association & Centers for Disease Control. (1991). *Healthy Communities 2000: Model Standards*. Washington, DC: American Public Health Association.
5. American Public Health Association & Centers for Disease Control. (1991). *Guide to Implementing Model Standards*. Washington, DC: American Public Health Association.
6. American School Food Service Foundation. (1991). *Healthy E.D.G.E. in Schools: Eating, Dietary Guidelines, and Education*. Alexandria, VA: American School Food Service Foundation of the American School Food Service Association.

7. American College of Sports Medicine. (1993). Hundreds of Healthy People 2000 volunteers help to promote the Healthy People 2000 physical activity objectives. *Sports Medicine Bulletin*, 28(1), 28 &31.
8. American College of Sports Medicine. (1993). Healthy People 2000 news. *Sports Medicine Bulletin*, 28(2), 26.
9. American College of Sports Medicine. (1993). Healthy People 2000 making big strides. *Sports Medicine Bulletin*, 28(3), 26.
10. American College of Sports Medicine. (1993). Grants available in 1994 for Healthy People 2000 activities. *Sports Medicine Bulletin*, 28(4), 23.
11. Brown, K.C., Mattson, A.H., Newman, K.D., and Sirles, A.T. (1992). A community health nursing curriculum and Healthy People 2000. *Clinical Nurse Specialist*, 6(4), 203-208.
12. Kligman, E.W., Kamerow, D.B., and Artz, L.M. (1990). Year 2000 health objectives and the family physician. *American Family Physician*, 42(3), 851-854.
13. McGinnis, J.M. (1989). National priorities in disease prevention. *Issues in Science and Technology*, Winter 1989-1990, 46-52.
14. McGinnis, J.M., Kanner, L., and DeGraw, C. (1991). Physical education's role in achieving national health objectives. *Research Quarterly for Exercise and Sport*, June 1991, 138-142.
15. Mikatavage, M.A. (1992). Industrial hygiene and national health objectives for the year 2000. *American Industrial Hygiene Association Journal*, 53(8), 528-530.
16. National Center for Health Statistics. (1993). *Health, United States, 1992 and Healthy People 2000 Review*. Hyattsville, MD: U.S. Department of Health and Human Services.
17. National Center for Health Statistics. (1993). Revisions to Healthy People 2000 Baselines. *Statistical Notes*, Number 5, July 1993. Hyattsville, MD: U.S. Department of Health and Human Services.
18. National Civic League. (1992). *Healthy Communities Directory*. Denver, CO: National Civic League.
19. National Civic League. (1993). *Healthy Communities Handbook*. Denver, CO: National Civic League.

National Health Promotion and Disease Prevention Objectives

20. National Civic League. (1991). *Healthy Communities Resource Guide*. Denver, CO: National Civic League.
21. National Resource Center on Worksite Health Promotion. (1991). *Healthy People 2000 at Work: Strategies for Employers*. Washington, DC: Washington Business Group on Health.
22. National Resource Center on Worksite Health Promotion. (1992). *Working for Good Health: Health Promotion and Small Business*. Washington, DC: Washington Business Group on Health.
23. National Resource Center on Worksite Health Promotion. (1992). *Directory of Worksite Health Promotion Resources*. Washington, DC: Washington Business Group on Health.
24. National Resource Center on Worksite Health Promotion. (1993). *The Worksite Health Promotion Sourcebook*. Washington, DC: Washington Business Group on Health.
25. Public Health Service. (1979). *Healthy People: Surgeon General's Report on Health Promotion and Disease Prevention*. Washington, DC: U.S. Government Printing Office.
26. Public Health Service. (1980). *Promoting Health/Preventing Disease: Objectives for the Nation*. Washington, DC: U.S. Government Printing Office.
27. Public Health Service. (1990). *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. Washington, DC: U.S. Government Printing Office.
28. Public Health Service. (1992). *Healthy People 2000: Consortium Action*. Washington, DC: U.S. Government Printing Office.
29. Public Health Service. (1992). *Healthy People 2000: Public Health Service Action*. Washington, DC: U.S. Government Printing Office.
30. Public Health Service. (1992). *Healthy People 2000: State Action*. Washington, DC: U.S. Government Printing Office.
31. Wellness Councils of America. (1991). *Healthy People 2000 at the Worksite*. Omaha, NE: Wellness Councils of America.

**ALABAMA'S HEALTH OBJECTIVES FOR THE YEAR 2000:
GETTING FROM HERE TO THERE¹**

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Simply having health objectives for Alabama for the Year 2000 is not enough. A strategy to achieve them is necessary. To catalyze the efforts to achieve the Objectives, the UAB School of Public Health Centers for Health Risk Assessment and Disease Prevention and Community Resource Development in cooperation with the Alabama Department of Public Health spearheaded a three-day conference beginning on October 28, 1991 entitled "Alabama's Health Objectives for the Year 2000: Getting from Here to There."

An Advisory Committee put the conference together (Table 1). It included not only representatives of the UAB School of Public Health, but also the Schools of Medicine, Nursing, Optometry, Dentistry, Health Related Professions and Education, the Injury Prevention Research Center, Center for Urban University Relations and Office of VP for Health Affairs at the University, the Alabama Departments of Public Health and Education and the Jefferson County Health Department, Alabama Cooperative Extension Service, Veterans Administration, Cooper Green Hospital, and major voluntary health organizations [including the American Red Cross, American Lung Association of Alabama, March of Dimes, American Heart Association]. Several planning meetings were held in Birmingham.

The conference was designed to provide up-to-date research on health and education issues, showcase effective program models and gain input, networking and commitment from attendees through action oriented work groups. It had three

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activities: speakers (Table 2), and caucuses (Table 3). Speakers were selected because of their prominent and effective role in programs or agencies with activities directed toward achieving the Objectives.

Each speaker was asked to describe programs which were successful and what attributes made them so. The choice of workshops [Table 2] was designed to provide practical information on methods to bring about community objectives: behavior modifications, education, screening, coalition building, risk assessment and legislation. Two workshops focused on business. Caucuses were organized according to specific age groups (pregnant women and infants, children, adolescents, adults, and elderly), risk factors (tobacco, alcohol, drugs, exercise, access to care, sensory impairment, nutrition, toxic exposure, social support) and locations (community, home, worksite, school, church, health provider office). Caucus groups were designed to allow each participant to explore these areas with others representing a broad array of professionals with whom they would rarely come in contact in the course of their daily activities. Convened by a leader, each caucus was charged with the following two-part task: examine their topic in light of Alabama's Year 2000 Health Objectives, and determine action steps to be taken to achieve them. Where appropriate, the groups were asked to address the needs of special groups, such as African-Americans.

The conference brought together over 300 invited community and state leaders (agency personnel, educators, business persons, clergy) for interaction with researchers, academicians, practitioners and each other. The Alabama Department of Public Health used it to introduce Alabama's Health Objectives for the Year 2000. This document was based on a series of statewide health forums to discuss "Healthy Alabama 2000" and a Taskforce established by the Department [see article in this issue].

In addition to the grass roots activism generated by caucus groups, several other continuing efforts from the conference are worth noting. First, two coalitions were galvanized by the conference -- the Alabama School Health Coalition and the Healthy Alabama Nutrition Coalition. They have developed mission statements and strategic plans for future action. Second, an effort to establish baseline data on physical fitness has been initiated. Under the leadership of Ken Francis, physicians, students and their families statewide participated in a series of surveys and assessments of determine knowledge, attitude, behavior and personal levels of physical fitness. Finally, following the conference, a letter was sent to over 2000 persons of similar backgrounds to the conference participants. The letter informed them about the conference and asked them if they wanted a copy of Alabama's Health Objectives for the Year 2000 and/or were interested in specific caucus groups. Over 200 responded. Mailing lists of these and other persons interested in specific caucus topics have been prepared and are available by calling 205-934-7132.

Alabama's Health Objectives for the Year 2000: Getting from Here to There

This paper is the distillation of the strategies and tactics which were identified by the speakers, workshops and caucuses as effective in attaining the Objectives. It is an action agenda.

I. Overhaul the Healthcare System

Both Earl Fox and Audrey Manley pointed out the necessity to overhaul the entire healthcare system to shift dollars from treatment to prevention. They proclaimed that political action would be required.

The Access caucus called for universal access as central to achieving the Objectives. Among the services for which improved access was recommended were screening, referral, immunizations, health education, and parenting education, growth and development assessment.

Statewide initiatives which were identified included:

- 1) Create a Governor's Council on Access to Care.
- 2) Expand the representation on the State Board of Health to include non-physicians.
- 3) Systematically address voluntary efforts by physicians (similar to pro bono with lawyers).

II. Action Can Best Be Taken Locally

While the national program, Healthy People 2000, provides the road map and the means of measurement, action could best be taken at the state, local, family and individual level.

III. Employ a Community Approach

The community approach is crucial because behavior is learned in the community, and reinforcement through peer pressure and advertisement are acting through the community. The community approach should:

- 1) Be comprehensive.
- 2) Have broad support from community leaders and health professionals.
- 3) Not disdain attention grabbing devices because they seem undignified. If funny costumes or contests get the preventive message across - do it.

- 4) Form partnerships with the community. Look for these among park services (e.g. running tracks), libraries (cholesterol screening in book mobiles) and city services.
- 5) Use elderly and handicapped persons as volunteers.
- 6) Work with restaurants, especially chefs and caterers, to encourage them to promote healthy foods.
- 7) Put people in positions which fit their personalities. Use extroverts to staff tables; let introverts run the machines; encourage social types to meet the public.
- 8) Use church bulletins and industry newsletters to disseminate information.

IV. Use Existing Educational Avenues

Education was identified by almost everyone as one of the most expeditious ways of addressing the health promotion, health protection, and health services needs. Schools were identified as an important focus for education efforts. Not only were children the target for educational efforts in the school, but also adults through PTA and community education programs.

V. Understand the Mores of Those to Whom the Prevention Message Is Addressed

Philip Porter argued that in order to effect change, the mores of the culture must be recognized and respected. He used as his example, adolescent use of a School Health Clinic. Putting pre-season exams for the football team in the School Health Clinic, made it acceptable for use.

VI. Target

Sharon Ramey pointed out that we are not reaching the people we need to reach. There is a need to look at subpopulations and differential vulnerability. We need to focus on the intervention process - why people in grave need don't seek out services or participate in intervention and outreach. Values and beliefs are at the heart of why many intervention and outreach efforts do not work for certain populations.

Specifically target the hard-to-reach:

rural

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poor

poorly educated

minorities

smoking households

isolated elderly

small businesses

VII. Put Programs Where Those Who Need It Are

As in real estate, the key is *location*. Again, schools were identified more than any other single agency as a point of contact to reach youth and families with programs and services that promote physical, mental, and social well-being. A goal of one school nurse for every 400 students was recommended. One example was a school health clinic in St. Paul which was put in the busiest part of school; easy to find, easy to reach. Daycare centers and housing projects were identified as other places to put programs.

VIII. Make Programs More Effective with Limited Resources

- 1) Reorganize existing programs in a creative way.
- 2) Use existing personnel in a new way. The Substance Abuse Caucus recommended use of non-mental health professionals for the treatment of substance abuse.
- 3) Promote grass-roots efforts to enable leaders to develop their own resources.
- 4) Share resources.
- 5) Stop re-inventing the wheel.

IX. Involve Others in Your Efforts

Andrew McGuire suggested:

- 1) Come to know and love the bureaucrats who have power over the issues that are important to you.

- 2) Develop coalitions with people outside the healthcare field.
- 3) Involve persons who have been personally affected by your issue. Be tactful in dealing with them. Where appropriate use them as a spokesperson.

X. Get Business Leaders Involved

In opening the conference, Earl Fox said, "The biggest problem we have on the local, state and national level, is to get the word out to the people who need to hear it. And by that I mean business leaders." Tom Lasiter recommended working with the Rotary Club to gain entre' to business.

XI. Make Health Consciousness Part of the Corporate Culture

William Baum suggested:

- 1) Setting a good health goal for the workers by corporations.
- 2) Revise health norms.

For example,

- a) if cigarettes are sold on the work site, stop it
- b) add healthy items to the cafeteria
- c) encourage exercise

The phases of norm-changing are:

- a) Start-up: Involve the employees. Help them recognize behaviors they need to change.
- b) Involvement: use multi-level chain strategies.
- c) Initiating change: Communicate! Send flyers home.
- d) Sustaining: This is the hardest and most important part. Do evaluations at all levels so that employees can appreciate their own successes. Foster competition, make programs fun, and allow freedom of choice.

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The Worksite Caucus recommended improving surveillance of worker health status and worksite health and safety activities.

XII. Establish Coalitions; Break Down Barriers to Interaction

Policy makers should work to remove barriers to learning, by supporting health and education and human service agencies should be promoted.

Tracy Stern recommended that states do the following to foster collaboration:

- 1) Provide incentives for community collaboration.
- 2) Combine funding streams through reallocation or redeployment of funds.
- 3) Implement case management strategies.
- 4) Combine budgets between sectors and agencies that service children and families.
- 5) Establish school based services for children and families.

Among the coalitions recommended were Nutrition, Physical Fitness, Adolescents, School Health, and vision.

XIII. Get on the Public Agenda

Three state legislators developed the following points for getting bills on the legislative agenda:

- 1) Find a champion, preferably a member of the committee which will be hearing it.
- 2) Use lobbyists. They are effective tools.
- 3) Begin by developing support for the bill in your home district.
- 4) Call your legislator... Show up in person... more than once.
- 5) Educate your legislator.
- 6) Meet with legislators before crisis develops. Get to them before you really need them.

Among the bills suggested were a Clean Indoor Air Act and vending machine restriction ordinances.

XIV. Use the News Media to Get Your Point Across

Among the points suggested by Tim Watkins of CNN:

- 1) Find ways to work with the media to get out its information. It is the role of the media to inform, not to educate.
- 2) Assist the news media with full information; prepare materials broadcasters can understand and interpret. Learn to use visuals. Keep the stories short. Use anecdotal evidence.
- 3) If necessary, hire someone who knows how to convey your message to the media.
- 4) Find a new angle on an old story.
- 5) Don't depend on T.V. Send stories to daily, weekly papers, regional monthly magazines. Radio is direct, immediate and cheap.
- 6) Call in your stories. Be persistent. If the reporters are not interested, go to the publisher, write a letter to the editor, or do an op-ed piece.

In addition, Andrew McGuire with the Trauma Foundation suggested:

- 7) Develop a personal relationship with people in the media. Get to know them before you need them.

XV. Train Health Care Providers in the Importance of Prevention and the Skills to Assist Patients to Change Behavior

Douglas Kamerow identified the following as important in putting clinical preventive services in practice:

- 1) Support financial reimbursement for preventive efforts. Preventive services should be covered with no deductibles. The College of Preventive Medicine has a primer of this subject "Paying for Preventive Care: Moving the Debate Forward" which can be obtained

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from 202-789-0003. Urge modification of Medicare, Medicaid, and private health insurance plans to cover preventive services.

- 2) Professional education must emphasize preventive skills. Another important focus was continuing education for health professionals. In many of the areas, this was considered essential.
- 3) Make clinicians aware of what is available and what ought to be done. "Putting Prevention into Practice" is an effort by the federal government to do this.
- 4) Conduct a survey of health providers regarding counseling about risk factors and prevention screening.
- 5) Establish a statewide health promotion clearinghouse.
- 6) Set up a systematic method of reminders because the press of daily activities leads to forgetting to do preventive intervention.

According to Linda Leininger, clinicians should:

- 1) Decide on their own prevention policy.
- 2) Work to change norms within organizations which influence practice patterns (Medical associations, HMO's, etc.).
- 3) Use patient education materials.
- 4) Prompt patients to use preventive services.
- 5) Provide recall and reminders of follow-up and patient-held "mini-records".
- 6) Involve office staff in the planning for preventive care including identifying patients who need services, giving out literature and reminding patients of needed tests.

XVI. Work with the Criminal Justice System

Ronald Garrison pointed out that the United States incarcerates more of its people than any other country in the world. Many prisoners are youthful offenders. Children are our poorest class of citizens. With an aging society, less and less resources are directed to children. There is a need to have a paradigm shift in schools and communities. Garrison recommended:

- 1) Teachers must receive adequate training to deal with high risk youth.
- 2) Collectively, our community of adults must take responsibility for all children.
- 3) Communities must come together to collaborate on problems of youth
- 4) Vertical Tracking Systems (case histories from multiple agencies) must be established for case management of high risk youth

The Tobacco caucus recommended increased enforcement of the law restricting tobacco sales to persons under age 19.

XVII. Empower Patients to Care for Themselves

According to John Renner, to do this:

- 1) Healthcare professionals should develop a partnership the patient.
- 2) Make sure any activity has consumer representation. Involve them in the decision making process.

Others recommended:

- 3) Mandate structured, age appropriate (K-12) comprehensive health education curriculum.
- 4) Stimulate consumer awareness to ask for counseling and screening.

XVIII. Use Your Numbers

- 1) Develop phone networks.
- 2) Write letters.
- 3) Hold rallies.

XIX. Increase Manpower

A need for more nurses, social workers, and registered dieticians was noted. In addition to these strategies to initiate activities, the speakers kept reminding the conference participants "to start is not enough."

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XX. Follow-Through Is Important

"Never, never, never, never give up." - Winston Churchill

XXI. Evaluate Your Activities

Sharon Ramey pointed out that as a democratic society we need to be selective in our decisions about funding programs. Research shows that offering a thin intervention program is not better than offering no program. Because time and money are limited in most settings, good evaluation provides the means to determine success and failure. This knowledge provides a basis for funding decisions and fine tuning program direction. It also allows identification of key elements for success that can have a positive impact on conservation of time. One way to do this is to have a yearly report card.

XXII. Remain Aware of the Long View - Be Tenacious and Persistent

Andrew McGuire reminded the Conference participants that his efforts to require fire retardant sleepwear took 20 years. This emphasis was supported by many of the speakers who urged tenaciousness and persistence.

XIII. Take Small Immediate Steps, Don't Wait

ACKNOWLEDGEMENTS

The "Healthy Alabama 2000" conference was supported primarily through inkind/donated services. In addition financial support was provided by the President, UAB Geriatric Education, UAB Injury, Alabama Public Health Association, UAB Office of the Prevention Center, UAB Office of Media Relations, UAB Office of Health Extension, Public Service and Research, Hanna Steel Corporation, Cooperative Health Manpower Education Program, Institute of Educational Leadership, and National Health/Education Consortium.

In addition to the Advisory Committee, speakers, workshop and caucus leaders, we are indebted to the following persons who made the conference a success:

Judy Baker
Pat Burchfield
Connie Cooper
Fletcher Harvey
Kitty Norrell
Dorothy Patterson

Roseman, Goodson, and Michelini

Table 1
ADVISORY COMMITTEE

Lynn Artz UAB School of Public Health	Jim McDermott American Heart Association
Robbie Barnes Jefferson County Department of Health	James McVay Alabama Department of Public Health
Vickie Barrett UAB Occupational Environmental Medical Clinic	Max Michael Cooper Green Hospital
Allen Bolton UAB Injury Prevention Research Center	Chuck Michelini UAB University Relations
Frank Brennan American Heart Association	Ouida Myers Alabama Department of Education
Raymer Clanton American Red Cross	Katrina Parker Children's Hospital
Steve Cooley UAB Governmental Relations	Marlon Priest UAB Office of Vice President for Health Affairs
Wendy DiMicco UAB School of Nursing	James Raczyński UAB General and Preventive Medicine
Rebecca Falkenberry UAB Center for Urban Affairs	Sue Rafferty Alabama Cooperative Extension Service
Melissa Galvin UAB School of Public Health	Sheron Rose Alabama Department of Public Health
John Gever UAB University Relations	Jeffrey Roseman UAB Center for Health Risk Assessment & Disease Prevention
Jay Goldman UAB School of Engineering Administration	Sharon Ryan UAB Occupational Medicine Program
Linda Goodson UAB School of Public Health	Paula Stanton UAB School of Public Health
Jack Hataway Alabama Department of Public Health	J. Stokes-Holloway Alabama Department of Public Health
Sceiva Holland Veteran's Administration Hospital	Barbara Struempler Auburn University
James Hughes American Lung Association of Alabama	Leroy "Dyke" Tilt March of Dimes
Timothy Key UAB Occupational Medicine Program	Betty Ward American Red Cross
Robert Kleinstein UAB Department of Optometry	Marilyn Wells Alabama Department of Public Health
David Macrina UAB Department of Health/Education/Physical Education	Odessa Woolfolk UAB Community Relations
	Allen Yoe Veteran's Administration Hospital

Alabama's Health Objectives for the Year 2000: Getting from Here to There

TABLE 2

SPEAKER	TOPIC
Claude Earl Fox, State Health Officer, Alabama State Department of Health	Healthy Alabama 2000
Audrey F. Manley, Deputy Assistant Secretary for Health, U.S. Department of Health and Human Services	Mobilizing for Action: A Blueprint for the 21st Century
Philip J. Porter, Director, Healthy Children, The Robert Wood Johnson Foundation	Healthy Children: A Message of Hope and a Plan for Success
William B. Baun, Manager, Health and Fitness, Tenneco Corporation	Healthy Adults: Corporate Culture and the Bottom Line
Mary S. Harper, Coordinator, Research and Development, White House Conference on Aging	Healthy Older Adults: How to Protect a Natural Resource
Tom Watkins, Producer, Medical Unit, Cable News Network (CNN)	Health and the Media in the 21st Century
Sandra J. McElhaney, Coordinator of Prevention, National Mental Health Association	Mental Health in the Year 2000
Andrew McGuire, Executive Director, Thr Trauma Foundation San Francisco General Hospital	Implementing Safer Technologies
Douglas B. Kamerow, Director, Clinical Preventive Services Staff, Office of Disease Prevention and Health Promotion	Clinical Services: Putting Prevention into Practice
Linda S. Leininger, Research Assistant Professor, University of North Carolina	Delivery of Effective Clinical Services for Disease Prevention and Health Promotion
Michael D. Parkinson, Deputy Director, Division of Associated Dental and Public Health Professions, Human Resources Services Administration	Financing Preventive Service
John Renner, President, Consumer Health Information Research Institute	The Educated Consumer/Patient
WORKSHOPS	
Moderator: David Coombs, Associate Professor, UAB, School of Public Health	COALITION BUILDING IN THE 90'S
Vee Stalker, Technical Advisor, County Health Council, UAB School of Public Health	County Health Councils
Susan Jenkins, Extension Sociologist-Community Wellness Programs, University of Georgia	Community-based Wellness Programs
Sharon Farley, National Kellogg Fellow, - Wilcox-Lowndes Counties, Auburn University at Montgomery	Developing Human Resources in Rural Communities
Harry Brown, Director of Planning, United Way of Central Alabama	Corporate Partnerships
Moderator: Melissa Galvin, Co-Director, Center for Community Health Resource Development, UAB School of Public Health	GETTING IT ON THE PUBLIC AGENDA
Senator Jim Bennett, 19th District - Jefferson Senator Ted Little, 27th District - Lee, Tallapoosa Senator Henry (Hank) Sanders, 23rd District - Choctaw, Dallas, Greene, Hale, Lowndes, Perry, Sumter and Wilcox	Legislative Panel

Roseman, Goodson, and Michelini

TABLE 2 (continued)

SPEAKER	TOPIC
Ronald W. Garrison, Consultant, Garrison and Associates: Child Advocacy Consultants	Child Advocacy for the 21st Century
Moderator: Joyce Moore, State Department of Education	EDUCATION AND HEALTH
Tracy P. Stern, Staff Member, National Health/Education Consortium	Crossing the Boundaries Between Health and Education
Wanda Jubb, Comprehensive School Health Coordinator, Centers for Disease Control	Comprehensive School Health
Sharon L. Ramey, Co-Director, UAB Civitan International Research Center	Effective Child and Family Intervention
Moderator: Robert Meeks, Professor, UAB, School of Public Health	ENVIRONMENTAL RISK ASSESSMENT
Charles Abernathy, Toxicologist, Human Risk Assessment Branch, Office of Water, United States Environmental Protection Agency	The Government
B. Suzi Ruhl, President and General Counsel, Legal Environmental Assistance Foundation	The Citizens
Jack Rigenbach, President, ERM-Enviroclean, Southeast	The Consultants
Moderator: Jeffrey Roseman, Director, Center for Health Risk Assessment and Disease Prevention, UAB School of Public Health	SCREENING FOR DISEASE
John Waterbor, Assistant Professor, Department of Epidemiology, UAB School of Public Health	Cancer
Elizabeth Lewis, Assistant Professor, Department of Preventive Medicine Clinic, UAB General and Preventive Medicine	Heart Disease
Robert N. Kleinstein, Professor and Chairman, UAB Department of Optometry	Diabetes
Conan Davis, Director, Dental Health Section, Alabama Department of Public Health	Dental
	CHANGING BEHAVIOR - WHAT HAVE WE LEARNED
James Raczynski, Associate Professor and Director of Behavioral Medicine Unit, UAB General and Preventive Medicine	
Thomas W. Lasater, Professor of Community Health, Brown University, Co-Principal Investigator, Pawtucket Heart and Health Program, Memorial Hospital of Rhode Island	
Moderator: Cathy Whiffield, American Heart Association, Alabama Affiliate	DEVELOPING A HEALTHY WORKFORCE
Margaret Beckham, Information Manager, Washington Business Group on Health	National Resource Center on Worksite Health Promotion
Susan Cheatwood, Nurse Practitioner, Health Services, Kimberly Clark	Occupational Health Nurses

Alabama's Health Objectives for the Year 2000: Getting from Here to There

TABLE 2 (continued)

LEADER	TOPIC
Michael Jarrett, Occupational Specialist for Public Health Nursing, Alabama Department of Public Health	Worksite Health Promotion
Mary Ruth Ayers, Assistant Administrator, Business and Finance Department, Fayette County Hospital	Heart-at-Work
	BUSINESS AND HEALTH ISSUES
Randy Richie, Assistant Director, State of Alabama Department of Industrial Relations	
Craig Donley, Assistant General Counsel, State of Alabama Department of Industrial Relations	
R. Craig Fulford, President, Health Services Review	
Rick Finch, Executive Vice President, Health Services Review	
Ada Hudson, Director of Provider Relations, Health Services Review	

Roseman, Goodson, and Michelini

TABLE 3

CAUCUS GROUPS	
LEADER	TOPIC
Dorothy Patterson, Coordinator of Avenues of Dialogue Between Adolescents, Parents, and Teachers (ADAPT), Jefferson County Health Department Leroy "Dyke" Tilt, Chapter Director, March of Dimes	Pregnant Women and Infants
Wendy DiMicco, Assistant Professor, UAB School of Nursing	Children
David M. Macrina, Coordinator of Health Education, School of Education, UAB Department of Health/Education/Physical Education	Adolescents
Lynn Artz, Former Senior Prevention Policy Advisor, Office of Disease Prevention and Health Promotion	Adults
Melissa Galvin, Associate Director, Center for Community Health Resource Development, UAB School of Public Health	Older Adults
Jack Hataway, Director, Center for Disability Prevention, Bureau of Health Promotion and Information, Alabama Department of Public Health	Tobacco
Charles Collins, Program Coordinator, Preventive Services, UAB Drug Free Program	Alcohol and Drugs
Max Michael, Chief of Staff, Cooper Green Hospital	Access to Care
Robert Meeks, Associate Professor, Environmental Toxicology Program, UAB School of Public Health	Toxic Exposure
Tom Struzick, Director of Continuing Education for AIDS Education, UAB School of Public Health	Sexually Transmitted Diseases
Robert Kleinstein, Professor and Chairman, UAB Department of Optometry	Sensory Impairment
Barbara Struempler, Nutrition Specialist, The Alabama Cooperative Extension Service, Auburn University	Nutrition
Kennon T. Francis, Professor, Division of Physical Therapy, UAB School of Health-Related Professions	Exercise
Miller Piggott, Program Coordinator, The Alzheimer Family Program, UAB Center for Aging	Social Support
Betty Ward, Director, Health and Youth Services, American Red Cross, Alabama Affiliate	Community
Marilyn Wells, Director, Division of Disease Prevention, Center for Disability Prevention, Bureau of Health Promotion and Information, Alabama Department of Public Health	Home

Alabama's Health Objectives for the Year 2000: Getting from Here to There

TABLE 3 (continued)

LEADER	TOPIC
Lynn Artz, Former Senior Prevention Policy Advisor, Office of Disease Prevention and Health Promotion	Worksite
Ouida Myers, Health Education Specialist, Elementary Instructional Services, Alabama Department of Public Health	School
Sceiva Holland, Director, Cooperative Health Manpower Education Program, TAHEC, Inc., Department of Veteran's Affairs, Medical Center/Tuskegee	Church
Jack Hataway, Director, Center for Disability Prevention, Bureau of Health Promotion and Information, Alabama Department of Public Health	Health Providers Office

PROGRESS TOWARD HEALTHY ALABAMA 2000 OBJECTIVES: A 1992 REVIEW*

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Healthy Alabama 2000 Coordinator

Jack Hataway, M.D., M.P.H.
Cancer Division Director

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ABSTRACT

Striving to prevent and control disease is vital to our nation's health. To assist in this endeavor, health care professionals throughout the nation developed health-related goals and objectives for the United States, known as *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. In addition to the national initiative, Alabama's health professionals felt that goals and objectives needed to be established for Alabama and these became known as *Healthy Alabama 2000 - Health Promotion and Disease Prevention Objectives For The Year 2000 - The Next Century Is Here*. This article briefly describes *Healthy People 2000* and *Healthy Alabama 2000*; however, the primary focus is on the objectives in *Healthy Alabama 2000*, including the baseline and update data and Year 2000 goal.

Through this progress report, Alabama's health professionals will have the opportunity to review the data to determine if the health care services need to be modified to better assist in reaching the Year 2000 goals.

INTRODUCTION

Healthy People 2000

Healthy People 2000: National Health Promotion and Disease Prevention Objectives is a national strategy developed to set goals for improving our nation's health by the year 2000. This document is a product of extensive public review and comment which included more than 10,000 people, nationwide.

*Manuscript received 31 August 1993; accepted 6 December 1993.

James Mason, M.D., Dr.P.H., the Assistant Secretary for Health, stated, "This set of objectives for the year 2000 makes an important, compelling point to us and to all health policy makers: we can no longer afford not to invest in prevention. From the perspective of avoiding human suffering as well as saving wasteful costs for treating diseases and injuries that could have been prevented, the 1990s should be the decade of prevention in the United States."¹

Healthy Alabama 2000

Healthy Alabama 2000 - Health Promotion and Disease Prevention Objectives For The Year 2000 - The Next Century Is Here is a statewide cooperative project which establishes a prevention agenda with quantifiable targets to improve health status, reduce risk factors for disease and disability, and improve services.² *Healthy Alabama 2000* is an offspring of the nationwide initiative, *Healthy People 2000*.

Claude Earl Fox, M.D., M.P.H., former Alabama State Health Officer, stated, "This document (*Healthy Alabama 2000*) contains measurable health objectives to cut the direct and indirect costs of poor health and to improve the length and quality of life of all Alabamians. This is both an exciting and challenging time: people have never lived longer, and for human and financial reasons, we must see that they never lived healthier."³

Original Document. During the development of the original document of *Healthy Alabama 2000*, a consortium of individuals, agencies, and organizations, known as the Healthy Alabama 2000 Task Force, was created. Seven regional meetings were held to receive consumer input and recommendations on what the health objectives for the state should include. A statewide meeting was held in April 1991, at which working groups made the final decisions using the U.S. D.H.H.S. *Healthy People 2000* document as a frame of reference. In October 1991, key political leaders, business persons, representatives from community organizations and agencies, and health professionals participated in a three-day statewide conference to seek their input and involvement in implementing the *Healthy Alabama 2000* objectives.

Healthy Alabama 2000 is divided into four sections, including 1) Chronic Diseases; 2) Communicable Diseases; 3) Environmental Health, Injury Control, and Occupational Safety and Health; and 4) Maternal, Reproductive, and Child Health. Each of the four sections is divided into at least two types of objectives: 1) Health Status

and 2) Risk Reduction. Sections one and four have an additional type of objectives, Service and Protection.

Progress Update Documents. The *Healthy Alabama 2000* Progress Update Documents are tools to monitor change from the baseline data toward the Year 2000 goal. By observing the change, health professionals are able to determine the

Healthy Alabama 2000 Objective: A 1992 Review

areas that need more attention and effort. This helps the health professional to better serve the public health sector.

The update process included: 1) developing update forms, including all of the objectives, baseline data, blanks for 1990, 1991, and 1992 data updates, and the Year 2000 goals; 2) identifying and communicating with the data source contacts for the objectives with a baseline data source; 3) sending the update forms to the data source contacts; 4) receiving and entering the 1990, 1991, and 1992 data into the computer; 5) completing data verification; 6) working with graphic personnel to develop format, design, and graphics for the update publication; 7) completing the publication process; and 8) disseminating the final update publication to health professionals statewide and other persons who request the document.

Healthy Alabama 2000 Mid-Course Review will include the data update and a discussion of the health promotion and disease prevention/control activities. Some health areas will be well established and others will develop during these years.

Healthy Alabama 2000 Final Report will consist of the same type of information as the *Healthy Alabama 2000 Mid-Course Review*, discussions regarding the progress made during the 1990s, and the direction needed during the next decade.

Healthy Alabama 2000 Objectives

This section is divided into three sub-sections according to the types of objectives in the *Healthy Alabama 2000* document. These include: 1) Health Status Objectives, 2) Risk Reduction Objectives, and 3) Service and Protection Objectives. Each of the three sub-sections explains the purpose for that type of objective and provides an example of how the different types relate to each other.

Health Status Objectives

The Health Status Objectives are related to diseases, injuries, deaths, or teenage pregnancies. Table 1 lists the Health Status Objectives, the corresponding baseline data, update data, and Year 2000 goals. The primary data source for the Health Status Objectives in sections one and four is the Alabama Department of Public Health, Center for Health Statistics. This Center houses the vital records and statistics for the state of Alabama, including birth, death, marriage and divorce records.

In the chronic diseases area, health professionals and medical scientists use mortality rates, usually presented as age-adjusted rates per 100,000. The purpose of monitoring those chronic diseases considered to be of great public health importance is prematurity of the illness, health care costs, or Years of Potential Life Lost. As an example of mortality rates, the coronary heart disease mortality rate for Alabama

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Table 1: Healthy Alabama 2000 Health Status Objectives

HEALTH STATUS OBJECTIVE	1989 BASELINE	1992 UPDATE	2000 GOAL
1.1 Cardiovascular Disease *			
a. Coronary Heart Disease	114.3	103.6	100.0
b. Strokes	35.7	32.4	30.0
1.2 Cancer *			
e. All Cancers	142.3	142.8	135.0
b. Lung Cancer	44.2	45.5	45.0
c. Breast Cancer	21.8	21.5	20.2
d. Uterine Cervix Cancer	4.0	3.5	2.0
a. Prostate Cancer	16.6	18.8	15.2
f. Colorectal Cancer	12.8	11.9	11.9
g. Skin Cancer	3.0	2.9	2.5
h. Oral Cavity & Pharynx Cancer	2.6	2.0	2.1
1.3 Chronic Obstructive Pulmonary Disease *	20.2	20.1	25.0
1.4 Diabetes *	10.7	12.0	9.0
1.5 Cirrhosis *	7.3	7.4	6.0
1.6 Chronic Disabling Conditions - Data in Percent (1985 Baseline)			
a. Proportion of Alabamians \geq 65 years of age who have difficulty in performing 2 or more personal care activities	4.4 - 6.8	Unavailable	3.75
2.1 Incidence of AIDS - Data in Number of Cases (1990 Baseline)	240	438	>500
2.2 HIV Prevalence in Pregnant Women - Data in per 1,000 Live Births (1990 Baseline) (1992 Update Data in per 10,000)	1	0.9	>0.5
2.6 Incidence of Gonorrhea *	508	436	330
2.7 Incidence of Primary and Secondary Syphilis *	35	25	16
2.8 Incidence of Congenital Syphilis *	11	19	1
2.9 Incidence of Tuberculosis (1990 Baseline)	11.3	10.3	4
2.10 Incidence of Vaccine-Preventable Disease (1990 Baseline)			
a. Diphtheria	0	0	0
b. Tetanus	2	1	0
c. Polio	0	0	0
d. Rubella	0	0	0
a. Measles	25	0	0
f. Pertussis	65	20	25
g. Mumps	19	114	0
3.1 Blood Lead Levels - Data in Percent	No Data	0.4	0
3.4 Unintentional Injury Deaths - Data in Percent *	47.3	44.6	35.0
3.5 Intentional Injury Deaths *			
a. Homicide - Total Population (Black males - Healthy Alabama 2000)	12.6	14.2	9.0
b. Suicide - Total Population (White males - Healthy Alabama 2000)	11.9	12.0	8.3
3.6 Nonfatal Intentional Injuries			
a. Child Abuse - Data per 1,000 <18	32.2	Unavailable	28.1
b. Spouse/Companion Abuse - Data Per 1,000 Females 20-59	10.5	Unavailable	9.5
c. Aged/Disabled Adult Abuse - Data Per 1,000 18+	2.4	Unavailable	2.4
d. Assaults - Data Per 1,000	3.9	6.2	3.5
e. Rapes - Data Per 100,000 Females 12+	67.6	70.0	60.3
3.7 Alcohol-Related Motor Vehicle Crash Deaths - Data in Percent (1989 Baseline - Corrected)	47.0	36.9	25.0
4.1 Infant Mortality Rate - Data in Per 1,000 Live Births (1990 Baseline)	10.9	10.5	8.0
4.2 Teenage Pregnancy - Data Per 1,000 Adolescent Females *	79.2	64.8	50.0

Note: Health Status Objectives 1.6 b-e, 1.7, 3.11, and 3.12 are not listed because these objectives have no state data at this point.

* - Please note that the 1989 data is adjusted because the estimated 1989 population, used in the baseline, was higher than the 1989 population as indicated by the 1990 census.

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decreased from 114.3 per 100,000 in 1989 to 103.6 per 100,000 in 1991. Please note that the 1989 data is adjusted and different from the original document because the estimated 1989 population, used in the baseline, was higher than the 1989 population as indicated by the 1990 census. The year 2000 target for this disease is 100.0 per 100,000. To meet this goal, the mortality rate decrease by 3.6 per 100,000 according to the 1992 data is necessary. Please note that the 1992 data are substantially lower than the 1990 and 1991 data, respectively 113.9 per 100,000 and 113.1 per 100,000. This decrease is being reviewed at this time. By monitoring the trend in the rate, health professionals are able to track the progress toward the objectives. One way to decrease this is to provide more counseling regarding reduction of risk factors which have been demonstrated to have a strong relationship to the disease and the rate of occurrence.

Risk Reduction Objectives

The Risk Reduction Objectives set goals to reduce the prevalence of identified risk factors. Risk factors are specific characteristics which place individuals or communities at increased risk for a disease, decreasing their quality of life and health. Many diseases are totally preventable through vaccines. Genetics plays a role in the development of some diseases (e.g., cancer and cardiovascular disease); however, people have the ability to reduce their risk of getting many diseases through nutrition (such as decreasing fat intake), exercise (e.g., walking 30 minutes for three times a week), eliminating unhealthy behaviors (for example, smoking), and regular health examinations. The important concept to remember is that individuals play a major role in their own health through decisions about behaviors which substantially increase or decrease their risk of getting a disease.

Table 2 lists the Risk Reduction Objectives, the corresponding baseline data, update data, and Year 2000 goal. These data come from many different sources.

This paragraph includes an example of the connection between Health Status Objectives and the Risk Reduction Objectives. Cardiovascular diseases (discussed in the above section) have many risk factors. These include age, male sex, high blood pressure, family history, high blood cholesterol, smoking, stress, diabetes, and physical inactivity. Some risk factors are not adjustable, such as increasing age. However, the individual clearly has the ability to reduce risk factors, such as smoking. Smoking cessation has a demonstrated outcome of a marked reduction (estimated at 25%) in cardiovascular events at the community level. The relationship of the smoking level, or prevalence, helps gauge potential success in reducing this major disease. This information serves as a resource to specifically target individuals or groups who are not reducing their smoking levels. For example, adults (18 years and older) surveyed in Alabama who reported smoking decreased from 22.4% in 1990 to 21.8% in 1992.

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The year 2000 goal for this risk reduction is 15%. This suggests that more effort is necessary to achieve the Year 2000 target to reduce the tobacco prevalence in Alabama by 6.8%.

Table 2: Healthy Alabama 2000 Risk Reduction Objectives

RISK REDUCTION OBJECTIVE	1989 BASELINE	1992 UPDATE	2000 GOAL
1.8 Tobacco Use - Data in Percent a. Cigarette Smoking - adults aged 18 and over (1990 Baseline) - adolescents aged 13-18 (1990 Baseline) (1991 Update)	22.4 33.7	21.8 27.8	15.0 15.0
b. Smokeless Tobacco Use - adults aged 18 and over (1988 Baseline) - adolescents aged 13-18 (1990 Baseline) (1991 Update)	6.8 14.4	5.6 16.5	4.0 4.0
1.9 Alcohol - Data in Percent	2.3	1.8	1.75
1.11 Blood Cholesterol Level - Data in Percent	24.0	Unavailable	20.0
1.12 Weight - Data in Percent	19.6	22.7	15.0
1.15 Physical Activity - Data in Percent a. adults aged 18 and over b. adolescents aged 13-18 (1990 Baseline)	8.4 34.0	Unavailable Unavailable	30.0 50.0
1.17 Dental Caries - Data in Percent - Children aged 6 - 8 (1990-91 Update) - Adolescents aged 15 (1990-91 Update)	No Data No Data	40.0 39.0	20.0 15.0
2.11 Immunizations, By Age 2 - Data in Percent (1990 Baseline) (1992 Update)	50.0	73.0	90.0
2.12 Immunizations, Grades K-12 - Data in Percent (1990 Baseline) (1992 Update)	98.0	98.8	98
3.8 Protective Equipment Usage in Vehicles - Data in Percent a. Child safety seats - aged 0-5 (1991 Baseline) b. Seatbelts - aged 6 and over (1991 Baseline) c. Helmet use - Bicycles (1991 Baseline) - Motorcycles (1991 Baseline)	57.9 46.3 8.0 60.0	60.2 56.8 Unavailable 100.0	70 70 50 80
3.10 Statewide Trauma System	None	None	Establish
4.3 Incidence of Low Birth Weight - Data Per 1,000 Births	8.3	8.5	6.0
4.4 High School Graduation Rates - Data in Percent	68.0	Unavailable	90.0
4.6 Breastfeeding (July 1991 Baseline)	23.0	Unavailable	75.0

Note: Risk Reduction Objectives 1.10, 1.12, 1.13, 1.16, 2.3, 2.4, 2.5, 3.2, 3.3, 3.9, 3.13, 4.5, and 4.7 are not listed because these objectives have no state data at this point.

Service and Protection Objectives

The Service and Protection Objectives, located only in sections one and four, identify goals for health care providers and professionals to improve the diagnostic and treatment capabilities; thus, better serving Alabamians. The provision of specific

Healthy Alabama 2000 Objective: A 1992 Review

preventive services improves an individual's ability to stay healthy or increases the chances of detecting a disease early enough to correct or modify the disease's course by altering health behavior to reduce the individual's risk factors.

Table 3 lists the Service and Protection Objectives, the corresponding baseline data, update data, and Year 2000 goal. Half of the objectives do not have identified baseline data. However, data sources are being investigated to answer these data needs.

Table 3: Healthy Alabama 2000 Service and Protection Objectives

SERVICE AND PROTECTION OBJECTIVE	1989 BASELINE	1991 UPDATE	2000 GOAL
1.19 Screening Tests - Data in Percent a. Blood Cholesterol, within the last year, adults aged 18 and over b. Blood Pressure, within the last year, adults aged 18 and over (1992 Update) c. Clinical Breast Exam & Mammogram - Ever, females aged 40 and over - Within past 1-3 years, females aged 50 and over	43.2 78.6 55.3 52.9	56.8 93.1 Unavailable Unavailable	50.0 90.0 80.0 60.0
1.20 Psychogeriatric Services - Data in Percent	>10.0	Unavailable	75.0
1.21 Mental Health Services - Data in Percent - Proportion of adult Alabamians in Need of Mental Health Care who Receive Mental Health Evaluation and Therapy - Proportion of Counties in Alabama that have a Program for Mental Health Education and Destigmatization that includes a mechanism to monitor effectiveness	15.4 No Data	Unavailable No Data	25.0 100.0
4.8 Prenatal Care - Data in Percent - Proportion of women who receive care in the first trimester - Proportion of women who receive risk-appropriate care - Proportion of women who receive screening and counseling opportunities for fetal abnormalities	73.1 No Data No Data	77.1 No Data No Data	90.0 90.0 90.0
4.9 Newborn Screening - Data in Percent (1990 Baseline) (1992 Update) - Proportion of newborns screened by State-sponsored programs for genetic disorders and other disabling conditions - Proportion of newborns testing positive for disease who receive appropriate treatment	95.0 85.0	98.0 89.0	99.0 90.0
4.11 Primary Care Services - Data in Percent	50.0	73.0	90.0

Note: Service and Protection Objectives 1.18, 4.10, 4.12, 4.13, and 4.14 are not listed because these objectives have no state data at this point.

The purpose of the following example is to demonstrate the connection between Risk Reduction Objectives and Service and Protection Objectives. One Service and Protection Objective addresses routine counseling by primary care

providers to patients about tobacco use cessation (Objective 1.8 reducing Tobacco Use is a Risk Reduction Objective), diet modification (Objectives 1.9 reducing the Intake of Alcohol, 1.13 reducing Dietary Fat Intake, and 1.14 increasing Complex Carbohydrates and Fiber-Containing Foods), and recommended screening tests. The provider needs to review the current level of counseling to determine the most appropriate staff to provide smoking cessation, nutrition, and other behavior modification counseling. This should result in an increase of the percentage of providers counseling with the most effective counseling programs.

SUMMARY

Health care entails more than prescribing medicine, administering shots/vaccines, and providing other treatments. The old saying "An ounce of prevention is worth a pound of cure" is very true. Much of the health care field is shifting from only treating disease to also trying to prevent disease.

Health care is two-fold: 1) health care professionals and 2) the individuals. Both are vital components to increasing the overall health of Alabamians.

Through monitoring *Healthy Alabama 2000* objectives, Alabama's health care professionals can review the data and determine which deficiencies they have the capabilities to address. For example, primary care physicians' counseling practices can address Objective 1.18 (increase to at least 75% the proportion of primary care providers who routinely counsel patients about tobacco use, diet modification, and recommended screening tests). Alabamians must accept their share of responsibility for their health and realize that they have the ability to improve their health as well as the health of the community and the state.

By addressing health through these two avenues (i.e., health care professionals and individuals), the probability of improving health and reaching the Year 2000 goals increases immensely.

ACKNOWLEDGEMENTS

Healthy Alabama 2000 data are collected from numerous sources statewide which allow the state to monitor these objectives. We thank all the people and organizations which provide data for this endeavor. Also, we thank Dr. Barb Struempler, Ms. Arrol Sheehan, and Ms. Melissa Harris for reviewing this document.

REFERENCES

1. *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. Washington, D.C.: U.S. Department of Health and Human Services; 1991. DHHS publication PHS 91-50212.

Healthy Alabama 2000 Objective: A 1992 Review

2. *A Time of Challenge - A Time of Opportunity, Annual Report of the State Health Officer.* Montgomery, AL: Alabama Department of Public Health; 1991. ADPH publication ADPH-P-A-15/Rev.2/92.
3. *Healthy Alabama 2000 - Health Promotion and Disease Prevention Objectives For The Year 2000 - The Next Century Is Here.* Montgomery, AL: Alabama Department of Public Health; 1991. ADPH publication ADPH-P-BHPI-182-10-91.

PROGRESS TOWARD NUTRITION-RELATED HEALTHY ALABAMA 2000 OBJECTIVES¹

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ABSTRACT

The nutrition-related objectives of Healthy Alabama 2000 are located in two of the four main sections, including section one, Chronic Diseases, and section four, Maternal, Reproductive and Child Health. The following highlights the success of and the progress made toward select objectives: 1) colorectal cancer deaths and the proportion of Alabamians who receive cholesterol and blood pressure screenings - met; 2) cardiovascular deaths - significant reduction; 3) infant mortality rate of 10.5 - lowest ever but still 2.5 above the goal; 4) pregnant women receiving prenatal care during the first trimester - increased 4 percent between 1989 and 1992 which is 12.9 percent below the goal of 90; and 5) intakes for fat, complex carbohydrate, and fiber - Alabama data not available.

Alabama health professionals responded to the need to address nutrition-related issues by forming the Healthy Alabama 2000 Nutrition Coalition. During the remainder of this decade, the Coalition will focus on the Healthy Alabama 2000 nutrition-related objectives.

INTRODUCTION

The overall goal of Healthy Alabama 2000 is to increase the life expectancy of Alabamians (1). Nutrition, too much or too little, influences one's current and future health. The Surgeon General's Report on Nutrition and Health (2) states, "that for the two out of three adult Americans who do not smoke and do not drink excessively, one personal choice seems to influence long-term health prospects more than any other: what we eat." Health statistics support this statement. Dietary factors are linked with five of the 10 leading causes of death: coronary heart disease, some types of cancer, stroke, noninsulin-dependent diabetes mellitus, and atherosclerosis. Three other major killers--cirrhosis of the liver, unintentional injuries, and suicides--are associated with excessive alcohol intake. In general, yesterday's under-nutrition has been replaced by today's over-nutrition.

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This report presents information on two different aspects of Healthy Alabama 2000. First, the progress of nutrition-related Healthy Alabama 2000 Objectives is provided. It is readily apparent that nutrition is an underlying theme of the Year 2000 Objectives due to the number of nutrition-related objectives. Second, a brief history and current activities of Healthy Alabama 2000 Nutrition Coalition are presented. The Nutrition Coalition, organized from recommendations at the Healthy Alabama 2000 meeting, "Getting from Here to There," focuses on the nutrition-related objectives during this decade.

This report illustrates that many of the nutrition-related objectives set forth at the kickoff meeting for Healthy Alabama 2000 in Spring 1991 are progressing toward the Year 2000 goals. In addition, Alabama professionals are cooperatively planning strategies to address these nutrition issues.

NUTRITION-RELATED HEALTHY ALABAMA 2000 OBJECTIVES

The Healthy Alabama 2000 Objectives are organized under four health sections (1). The influence of nutrition is closely associated with only two sections: Chronic Diseases (Section 1) and Maternal, Reproductive, and Child Health (Section 4). Table 1 lists the nutrition-related objectives, 1989 baseline data, 1992 update data, and Year 2000 goals. The primary source for the 1989 and 1992 data is the Alabama Department of Public Health (ADPH), Center for Health Statistics. The prominence of nutrition-related objectives highlights the importance of nutrition in these two health areas.

In contrast, nutrition relationships are virtually nonexistent for the two other health sections. There are no nutrition-related objectives in Communicable Diseases (Section 2). For Environmental Health, Injury Control/Occupational Safety and Health (Section 3), only a weak nutrition relationship exists. The Year 2000 target to reduce the prevalence of blood lead levels among children (Objective 3.1) has an insignificant link to nutrition.

Chronic Diseases

Four out of seven Health Status Objectives listed under Chronic Diseases have nutrition implications (Table 1). They are cardiovascular diseases (Objective 1.1); some types of cancer, such as breast cancer (Objective 1.2c) and colorectal cancer (Objective 1.2f); diabetes (Objective 1.4); and cirrhosis (Objective 1.5).

Cardiovascular diseases (CVD), primarily coronary heart disease and stroke, continue to be the leading cause of death in Alabama. However, deaths from CVD have been reduced more than the other Chronic Diseases. Interestingly, the 1992 mortality rates for both coronary heart disease (103.6) and stroke (32.4) are quickly approaching the Year 2000 goals of 100 and 30 deaths per 100,000, respectively.

Progress Toward Nutrition-Related Healthy Alabama 2000 Objectives

While there has been little change in death rate from breast cancer during the past three years, the Year 2000 target for colorectal cancer of 11.9 has been met. There is no explanation for the slight increase in the diabetes mortality rate from 10.7 deaths per 100,000 in 1989 to 12.0 deaths per 100,000 in 1992. Death rate from cirrhosis remains essentially unchanged since 1989 baseline value.

It is widely accepted that changes in an individual's lifestyle makes a difference in health. Of the 10 Risk Reduction Objectives associated with Chronic Diseases, six relate to nutrition (Table 1). These major modifiable risk factors include drinking alcohol only in moderation (Objective 1.9); controlling blood pressure (Objective 1.10); reducing blood cholesterol levels (Objective 1.11); achieving and maintaining healthy body weight (Objective 1.12); decreasing fat intake (Objective 1.13); and increasing consumption of complex carbohydrates and fiber-containing foods (Objective 1.14). It is evident that encouraging healthy choices in diet and weight control, as well as exercise and other risk factors for disease, are major themes throughout the Chronic Diseases Objectives.

Although it is well recognized that chronic diseases are multi-factorial in origin, the effect of nutrition is often under-emphasized. Moreover, dietary intervention is often the cornerstone treatment for chronic diseases. For example, the major modifiable risk factors for CVD are high blood pressure, high blood cholesterol, and smoking. Once diagnosed with high blood pressure, dietary intervention includes limiting alcohol, sodium and fat intakes; losing weight or maintaining desirable body weight; and increasing complex carbohydrate/fiber intake. With the exception of sodium restriction, similar dietary guidelines are provided for those with high blood cholesterol levels. While it is impossible to provide a thorough discussion of these nutrition-related risk factors, all are Risk Reduction Objectives except for sodium (Table 1). In addition, other related Objectives to CVD include tobacco use (Objective 1.8), physical activity (Objective 1.15) and chronic disabling conditions (Objective 1.6), as well as diabetes (Objective 1.4).

Alabamians and other Americans continue to lose the battle of the bulge. In 1991, 30 percent of Alabama's adult population is considered to be overweight, according to ADPH, Risk Surveillance Division. There has been a steady increase in the total number of overweight individuals since 1986. At that time, 23 percent of Alabamians were overweight. The Year 2000 goal is to reduce the proportion of Alabamians age 18 and over who are overweight to no more than 15 percent (Objective 1.12). (For this discussion, overweight is defined as weight to height greater than 120 percent of the median.) Table 1 shows the proportion of Alabamians who are overweight based on body mass index. Fewer Alabamians are overweight when based on body mass index compared to weight to height.

It is impossible to measure Alabama's progress toward some Year 2000 targets due to insufficient data. Two examples are dietary fat intake (Objective 1.13) and

complex carbohydrates and fiber-containing foods (Objective 1.14). However, ADPH is making progress toward a data collection system. It is anticipated that mid-course and final Healthy Alabama 2000 reports will include information in these areas.

Although baseline data is not available for dietary fat intake (Objective 1.13), the Alabama 2000 target mirrors national recommendations (3). Similar goals are for 30 percent or less of total calories to come from total fat and 10 percent or less of total calories to come from saturated fat. These goals parallel those in Dietary Guidelines for Americans (4), Food Guide Pyramid (5), and the new food labeling guidelines (6). National average dietary fat intake remains at 36 percent of calories from fat and 13 percent from saturated fat (3).

Although Alabama baseline data do not exist for carbohydrate and fiber intakes, the Year 2000 goal is to increase dietary intake of complex carbohydrates and fiber-containing foods to five or more daily servings of fruits and vegetables and six or more daily servings of grain products (Objectives 1.14). This is similar to the national Healthy People 2000 Objective 2.6 (3).

While there are unresolved issues related to the beneficial effects of fibers, current evidence suggests the prudence of increasing consumption of grain products, vegetables (including dried beans and peas), and fruits. In general, a high-complex carbohydrate/fiber intake helps manage body weight, controls blood cholesterol levels, assists in diabetes management, prevents constipation, and protects against certain types of cancers.

It is interesting that the Year 2000 goals for dietary fat intake (Objective 1.13) and complex carbohydrates and fiber-containing foods (Objective 1.14) are for Alabamians age 2 and over. In contrast, most Chronic Diseases Objectives are targeted for those 18 years and over. It is generally agreed that a low fat, high carbohydrate/fiber intake is acceptable for all Americans age 2 and over. This philosophy is emphasized throughout Healthy Alabama 2000 Objectives. For example, healthy eating needs to begin at preschool (Objective 4.13) and continue throughout one's school years (Objective 4.14). Adults also need continuous training through worksite health programs (Objective 3.13f). Dietary modifications are usually not advisable for those less than 2 years of age.

One method to improve health status of Alabamians is through the services offered by primary care providers. The Year 2000 goal is to increase to at least 75 percent the proportion of primary care providers who routinely counsel patients about diet modification and other topics (Objective 1.18). Alabama baseline data are not available for the primary care providers objectives (Table 1).

The proportion of Alabamians who receive nutrition-related screening tests for cholesterol (Objective 1.19a) and blood pressure (Objective 1.19b) show excellent

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progress. For cholesterol, the Year 2000 goal of 50 percent of Alabamians having blood cholesterol checked within the last year has been met (Table 1). In 1991, 56.8 percent of Alabamians reported having a blood cholesterol test. This compares to 43.2 percent in 1989. This 13-percent increase in cholesterol screening over a two-year period parallels the prevalence of cholesterol education programs throughout Alabama.

Unfortunately, current information is not available on the proportion of Alabamians who have reduced blood cholesterol levels to less than 240 mg/dl. In 1989, 24 percent of Alabamians had blood cholesterol levels of 240 mg/dl or greater (Objective 1.11, Table 1). This blood cholesterol level is considered high-risk for coronary heart disease and is a risk factor which may be modified by nutrition intervention.

Blood pressure screenings are still popular in Alabama. In 1992, 93.1 percent of Alabamians reported having a blood pressure check (Objective 1.19b, Table 1). This exceeds the Year 2000 goal of 90. While it is promising that most Alabamians have a blood pressure check, the compliance to hypertension treatment is equally important in terms of economic and human health. Data do not exist for hypertensives not controlled in Alabama; 88.9 percent of hypertensives were not controlled in the United States in 1986 (3). This statistic highlights an alarming health problem. The Year 2000 goal is to decrease by 10 percent the proportion of Alabamians age 18 and over with high blood pressure whose blood pressure is not controlled (Objective 1.10).

Maternal, Reproductive, and Child Health

The potential for a long, healthy life is affected by the period before birth and the years of childhood and adolescence. Adequate nutrition and sensible food choices during these periods are critical to the quality of later life. Therefore, nutrition-related objectives are prominent throughout Healthy Alabama 2000 Maternal, Reproductive, and Child Health (Section 4, Table 1).

Infant mortality is a major health problem not only in Alabama, but also in the United States. In fact, the United States infant mortality rate remains higher than that of most other industrialized nations (7). Infant mortality rate is a broad indicator for a number of factors affecting the health of babies and their mothers. It has been called the "tip of the iceberg" of child health problems (8). While the rate actually indicates the number of babies that do not celebrate their first birthday, it ultimately reflects the availability and effectiveness of health care for a much larger population than those directly affected.

In 1992, the infant mortality rate in Alabama was the lowest ever recorded in the state, 10.5 deaths per 1,000 live births (Objective 4.1, Table 1). This low rate is not

by chance, but rather by considerable statewide efforts. In 1986, Alabama had an infant mortality rate of 13.3--the highest rate of any state in the nation (Figure 1). When this sobering finding was announced, coordinated efforts by numerous Alabama agencies and organizations were developed. New programs and networks were created including nutrition-education and health-awareness classes for pregnant women, especially those of limited-income. Toll-free hotline numbers for pregnancy information and referral and coupon incentive programs were also established. In fact, the steady improvement in Alabama's infant mortality rate has been credited to the conscientious and combined efforts of private health care providers and public agencies (9).

The Alabama infant mortality statistics show disproportionately high rates among the non-white, mainly black, population (Figure 2). In 1992, the 15.8 infant mortality rate among blacks was well above the Alabama rate of 10.5. In contrast, the 7.5 infant mortality rate among whites is one-half the black infant mortality rate and below Alabama's 2000 goal of 8.

The infant mortality rates of black Americans have been approximately double those of white Americans for more than 45 years. Although the rates have declined for both populations, the disproportionately high rates for blacks are unacceptable. This issue is specially addressed in Healthy Alabama 2000. The Year 2000 goal for infant mortality rate among blacks is 11 per 1,000 live births or less (Objective 4.1a, Table 1).

Teenage pregnancy occurs in all regions of the country, all ethnic groups, and all socioeconomic levels. In 1989, 79.2 per 1,000 adolescent females in Alabama became pregnant. By 1991, this number decreased to 75.5. No explanation is available for the major decline to 64.8 in 1992. Alabama still has a long way to go to meet the target to reduce pregnancies to no more than 50 per 1,000 females age 15 to 17 (Objective 4.2, Table 1). The most sobering aspect of teenage pregnancy is based on the report that one-fourth of teenagers who deliver a baby at age 16 or younger deliver a second baby within 24 months (10).

Nutritional status is one of the more modifiable variables affecting the health of the pregnant adolescent and the outcome of her pregnancy. The position of the American Dietetic Association is "that pregnant adolescents as a group are nutritionally at risk and require nutrition intervention early and throughout the duration of their pregnancies" (10). In addition to the teenager's normal growth requirement, the caloric and nutrient needs of the pregnant teenager must be sufficient to achieve optimum weight gain of the fetus.

Low birth weight of infants (2,500 grams or less) is a major contributor to infant mortality. Alabama's 2000 goal is to reduce the incidence of low birth-weight babies to 6 percent per 1,000 live births (Objective 4.3, Table 1). Although the incidence of

low birth weight in Alabama is more than 8 percent, it has not changed appreciably since 1989. Nutrition does influence on two major determinants of infant birth weight. They are prenatal weight gain and mother's prepregnancy weight status. No statewide data exist for these indicators of infant birth weight.

Statistics on the prevalence of mothers who breastfeed in Alabama are limited to mothers enrolled in the Women, Infants, and Children (WIC) program through ADPH. Only 23 percent of low-income mothers breastfed in the postpartum period in July 1991. Alabama's 2000 goal -- to have at least 75 percent of mothers breastfeed their babies during the six-week postpartum periods -- appears remote (Objective 4.6, Table 1). Nationally, 54 percent of mothers breastfeed at discharge from the hospital (3).

Information is not available on iron deficiency in Alabama. Similar to the national goal (3), Alabama's target is to reduce iron deficiency to less than 3 percent among children age 1 to 4 and among women of childbearing age (Objective 4.7, Table 1).

Iron deficiency in childhood may have adverse effects on growth and development. It is more common in black children, compared to white children, and those of low income (3). Ways to reduce iron deficiency among children are to increase breastfeeding, increase use of iron-fortified formulas, and delay the introduction of whole cow milk feedings until 12 months of age. To reduce iron deficiency in women of childbearing age, nutrition education should encourage the selection of iron-rich foods and provide adequate iron supplementation during pregnancy.

Alabama is making progress in the proportion of pregnant women who receive prenatal care in the first trimester. The Year 2000 goal is to increase to at least 90 percent pregnant women who receive prenatal care in the first trimester. In Alabama, the percentage of pregnant females who began care in the first trimester rose from 73 to 75 to 77 in 1989, 1991, and 1992, respectively (Objective 4.8, Table 1). Lack of or inadequate prenatal care is another major risk factor associated with low birth weight. Nutrition education is an important aspect of prenatal care. Healthy moms have healthy babies.

The Healthy Alabama 2000 goal is for all preschool children to have access to high-quality and developmentally-appropriate programs (Objective 4.13, Table 1). In terms of nutrition, this means an increase in the proportion of child-care food services (and school lunch and breakfast services) with menus that are consistent with the nutrition principles in the Dietary Guidelines for Americans (4). This federal document represents the best principles of healthy dietary practices and offers guidance for meal planning.

The Year 2000 goal for school health programs is to increase to at least 50 percent the proportion of schools providing all students with a comprehensive school

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health program (Objective 4.14, Table 1). This type of program includes six types of elements, ranging from environmental issues to counseling.

Nutritious meals and nutrition education are components of a comprehensive school health program. Similar to the national goal (3), Alabama's schools need to provide nutrition education from preschool through 12th grade as part of a quality school health program. At present, nutrition education is usually taught in health and home economic courses, although science and related curricula serve to reinforce principles and messages. However, it seems obvious that since nutrition impacts on health, the earlier the concept is taught to today's youth, the earlier they will adopt healthy dietary practices.

HEALTHY ALABAMA 2000 NUTRITION COALITION

Healthy Alabama 2000 Nutrition Coalition is a cooperative effort by statewide agencies and organizations to address the nutrition-related Healthy Alabama 2000 Objectives. The mission of the Healthy Alabama 2000 Nutrition Coalition is to promote healthy lifestyles through positive changes in nutrition and physical activity to achieve the nutrition-related objectives. As concerned individuals and professionals, Coalition members feel that they can make progress toward meeting the Objectives. To make individual contributions most effective, activities that are supportive of the Objectives must be integrated into each member's programs.

The Nutrition Coalition was organized as a result of recommendations from the conference, Healthy Alabama 2000 "Getting from Here to There." During this October 1991 meeting, nutritionists and other health professionals recommended that a nutrition network be established in Alabama to facilitate nutrition-related Healthy Alabama 2000 Objectives. This recommendation was unanimously accepted by those in attendance. The Alabama Cooperative Extension Service at Auburn University was the lead organization.

Only eight months after the recommendation for a Healthy Alabama 2000 Nutrition Coalition, the kick-off meeting was held in June 1992. Approximately 100 professionals, mainly school food service employees and those working with pregnant females, attended the statewide meeting in Montgomery. The goal was to begin communicating, exploring, sharing, and learning through and from those interested in nutrition-related health problems. Facilitators of the meeting were Auburn University (Alabama Cooperative Extension Service), ADPH (Bureau of Health Promotion and Information), and University of Alabama at Birmingham (School of Public Health).

In October 1992, quarterly meetings of the Healthy Alabama 2000 Nutrition Coalition began. There are currently 31 members, representing organizations, agencies, societies, universities, worksites, and food producers. While many members are nutritionists/dietitians, a diverse membership is encouraged and includes nurses,

Progress Toward Nutrition-Related Healthy Alabama 2000 Objectives

physical education specialists, health educators, and grocery store representatives. As the Nutrition Coalition bylaws state, "any individual or group that promotes healthy lifestyles through nutrition and physical activity can be a member."

During its first year, the Nutrition Coalition is focusing on the two objectives of reducing dietary fat (Objective 1.13) and increasing complex carbohydrates and fiber-containing foods (Objective 1.14). The main activity to support these objectives has been to adopt and promote the "5 a Day" message of the National Cancer Institute (11). This educational and mass media program emphasizes five or more daily servings of fruits and vegetables. To promote this program, the Coalition members individually integrate the message into their daily practices, as well as collectively make the message a part of the Nutrition Coalition's agenda. For example, all eligible members of the Coalition are sub-licensed through ADPH to distribute "5 a Day" materials. As part of the Coalition, the information is disseminated through committees to include schools, worksite/community, senior centers, and mass media.

SUMMARY

The prominence of nutrition-related Healthy Alabama 2000 Objectives indicates the importance of nutrition throughout the lifecycle. Most certainly, improved nutrition plays a major role in the improvement of public health.

Alabama is making progress toward many of the nutrition-related Year 2000 goals. Deaths due to CVD are reduced. Alabama's 2000 goals are met for deaths from colorectal cancer and screening tests for blood cholesterol and blood pressure. The overall infant mortality rate is the lowest ever with more pregnant females receiving prenatal care during the first trimester.

The nutrition-related Healthy Alabama 2000 Objectives provide the opportunity for professionals to strategically address the issues over the next decade. Alabama is accepting this challenge. Healthy Alabama 2000 Nutrition Coalition provides the unique opportunity for professionals to network, plan strategies, and adopt messages that promote good health through improved nutrition. With limited budgets and manpower, nutrition and health professionals need to develop plans to integrate activities that support the Objectives into their program's activities. It is only by working together that the contributions will be most effective.

ACKNOWLEDGEMENTS

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REFERENCES

1. Healthy Alabama 2000 - Health Promotion and Disease Prevention Objectives for the Year 2000 - The Next Century Is Here. Montgomery, AL: Alabama Department of Public Health; 1991. ADPH-H-BHPI-182-10-91.
2. The Surgeon General's Report on Nutrition and Health. Washington, DC: Public Health Service, U.S. Department of Health and Human Services; 1988. DHHS(PHS) 88-50210.
3. Healthy People 2000: National Health Promotion and Disease Prevention Objectives. Washington, D.C.: U.S. Department of Health and Human Services; 1991. DHHS(PHS) 91-50212.
4. Dietary Guidelines for Americans. Washington, DC: U.S. Department of Agriculture, U.S. Department of Health and Human Services; 1990. Home and Garden Bulletin 232.
5. The Food Guide Pyramid. Washington, DC: U.S. Department of Agriculture, U.S. Department of Health and Human Services; 1992. Home and Garden Bulletin 252.
6. FDA Consumer, Special Report: Focus on Food Labeling. Washington, DC: Food and Drug Administration; May 1993.
7. State of America's Children. Washington, DC: Childrens Defense Fund; 1992. ISBN 0-938008-92-7.
8. Daniel, W.A., D.A. Cornely and M.C. McCormick. Statement of Infant Mortality. Pediatrics: 1986, 78:1155-60.
9. State's Infant Mortality Rate Declines in '92. Montgomery, AL: Alabama Department of Public Health: Alabama's Health: June 1993, pg 2.
10. Position of the American Dietetic Association: Nutrition Management of Adolescent Pregnancy. Journal of the American Dietetic Association: 1989. 89:104-109.
11. 5 a Day Week Handbook. Newark, DE: Produce for Better Health Foundation, June 1993.

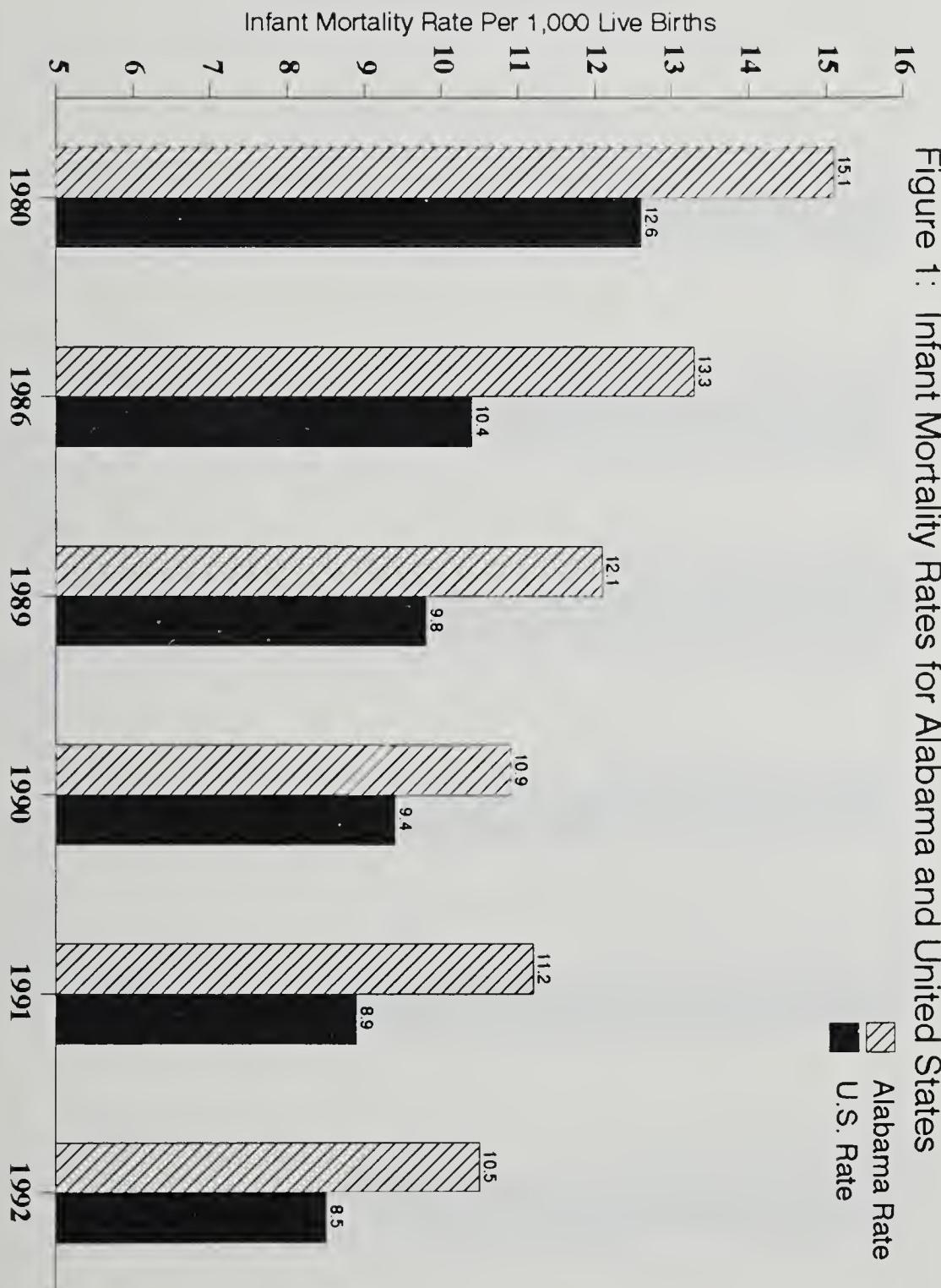
Progress Toward Nutrition-Related Healthy Alabama 2000 Objectives

**Table 1: Progress Toward Healthy Alabama 2000
Nutrition-Related Objectives**

	1989 Baseline*	1992 Update*	2000 Goal
1. Chronic Diseases			
1.1 Cardiovascular Diseases a. Coronary Heart Disease b. Strokes	114.3 35.7	103.6 32.4	100.0 30.0
1.2 Cancer c. Breast Cancer f. Colorectal Cancer	21.8 12.8	21.5 11.9	20.2 11.9
1.4 Diabetes	10.7	12.0	9.0
1.5 Cirrhosis	7.3	7.4	6.0
Chronic Diseases Risk Reduction Objectives			
1.9 Alcohol - Data in Percent	2.3	1.8	1.75
1.10 Blood Pressure - Goal: a 10% Decrease in Baseline	No Data	Unavailable	10.0
1.11 Blood Cholesterol Level - Data in Percent	24.0	Unavailable	20.0
1.12 Weight (Body Mass Index) - Data in Percent	19.6	22.7	15.0
1.13 Dietary Fat Intake - Data in Percent	No Data	Unavailable	30.0
1.14 Complex Carbohydrates & Fiber Containing Foods - See this review for goals	No Data	Unavailable	
Chronic Diseases Service & Protection Objectives			
1.18 Primary Care Providers - Data in percent	No Data	No Data	75.0
1.19 Screening Tests - Data in Percent a. Blood Cholesterol, within the last year, adults age 18 and over b. Blood Pressure, within the last year, adults age 18 and over (1991 Update: 91.5)	43.2 78.6	56.8** 93.1	50.0 90.0
4. Maternal, Reproductive & Child Health			
4.1 Infant Mortality Rate - Data Per 1000 Live Births a. Infant Mortality Rate Among Blacks	12.1 15.9	10.5 15.8	8.0 11.0
4.2 Teenage Pregnancy - Data Per 1000 Adolescent Females (1991 Update: 75.5)	79.2	64.8	50.0
Maternal, Reproductive and Child Health Risk Reduction Objectives			
4.3 Incidence of Low Birth Weight - Data Per 1000 Live Births	8.3	8.5	6.0
4.6 Breastfeeding - Data in Percent (Baseline: low-income mothers, July, 1991)	23.0	Unavailable	75.0
4.7 Iron Deficiency - Data in Percent	No Data	No Data	3.0
Maternal, Child & Reproductive Health Services & Protection Objectives			
4.8 Prenatal Care - Data in Percent	73.1	77.1	90.0
4.13 Preschool Programs - See this Review for Goals			
4.14 School Health Programs-See this Review for Goals a. Nutritious Meals b. Nutrition Education			

*Source: Alabama Department of Public Health, Center for Health Statistics

**1991 Update



Progress Toward Nutrition-Related Healthy Alabama 2000 Objectives

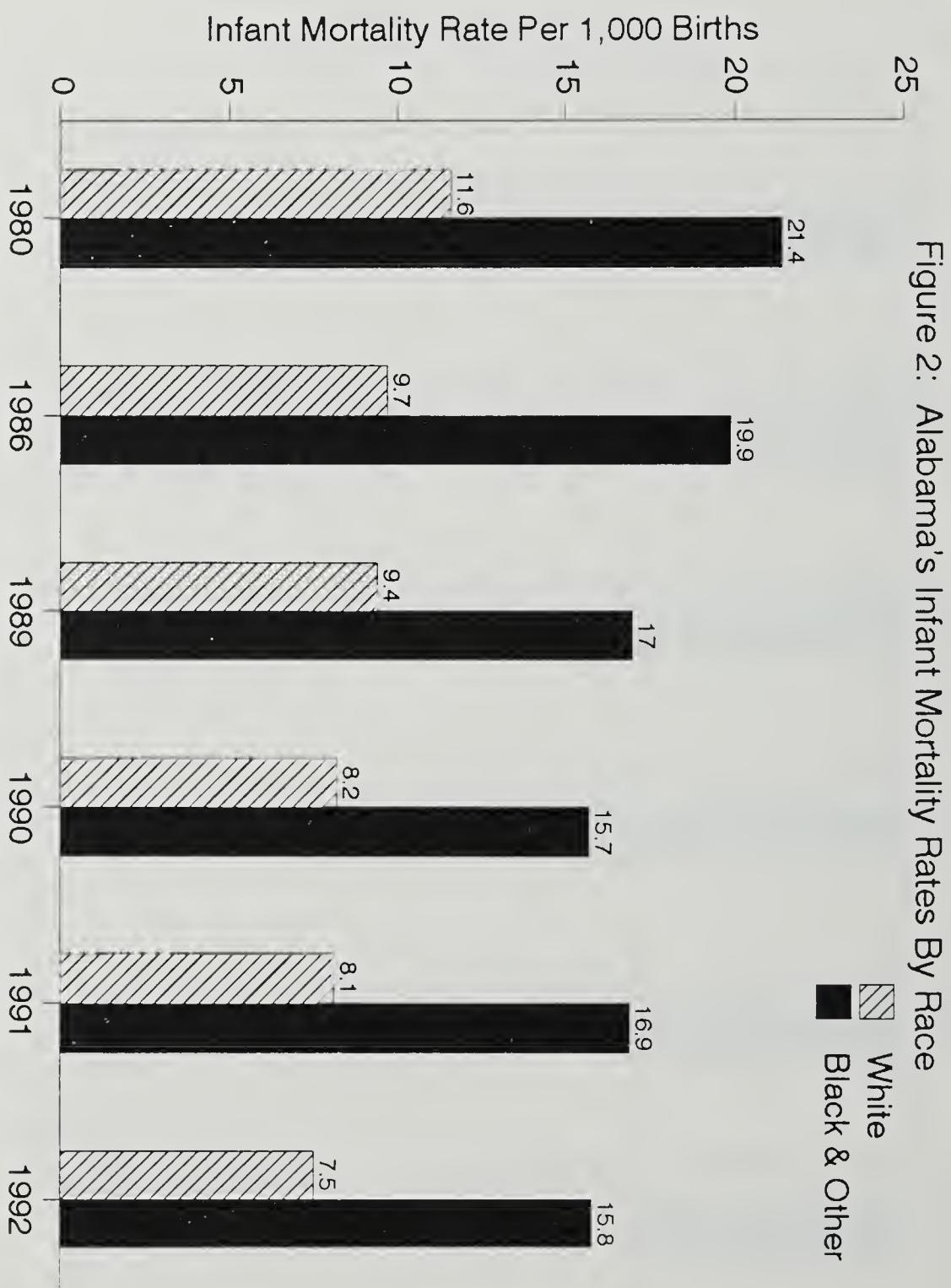


Figure 2: Alabama's Infant Mortality Rates By Race

PHYSICAL FITNESS AND HEALTHY PEOPLE 2000¹

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INTRODUCTION

We are in a time of great change with regard to our health status. Americans seem to have more interest today than ever before in the state of their health and how they can prevent disease. This concern is driven partially due to the exponential rise in health care cost and the desire to remain healthy and avoid costly hospitalization. Today Americans spend more on health care than on either education or national defense (14,26). In 1988, six percent of the gross domestic product (GDP) was spent on health care (14). In the last two decades, the proportion of the GDP spent on education and national defense has decreased, while the proportion for health care has increased 50 percent, even after adjusting for economy-wide inflation (14,26). Not only is the general public interested in a healthier America, but the government is also making a strong effort to improve the health of the nation.

In September 1990 *Healthy People 2000*, the health promotion and disease prevention objectives for the nation for the decade of the 1990's, was released (11). These 300 measurable objectives, established among 22 priority areas, serve as the nation's public health agenda for the 1990's. Because so much has been learned in the past 20 years about the importance of regular physical activity to health status, it is not surprising that in the development of the year 2000 health objectives, great emphasis was placed on reducing sedentary lifestyles and increasing moderate daily physical activity among Americans.

IMPORTANCE OF PHYSICAL ACTIVITY

Physical activity that builds endurance and flexibility has been shown not only to protect against injury and disability but directly reduce the risk for several major chronic diseases as well as to catalyze positive changes with respect to other risk factors. For example, increased levels of physical activity has been shown to be associated with lower risk of coronary heart disease (CHD) (10,23,28,), diabetes (28), hypertension (9,12) colon cancer (28), stroke (23) and obesity (10,28). Caspersen (4)

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in a meta-analysis critique of 43 epidemiological studies assessing the relationship of physical activity to CHD, concluded that there is a direct relationship of lack of exposure of physical activity and the development of CHD. The lack of regular physical activity is an independent risk factor for the development of CHD and a sedentary person is 1.9 times more likely to develop CHD than an active one (4). Regular physical activity has been shown to reduce the risk of all-cause mortality by more than 25% (24) and to increase life expectancy by more than 2 years over the population average (27).

Of the various independent risk factors, sedentary lifestyle has been ascribed as the most prevalent (58%) modifiable risk factor for reducing CHD, followed by cigarette smoking (25%), obesity (22%), hypertension (17%) and diabetes (5%) (4). These conclusions are important in light of the striking number of deaths from CHD that continue to plague Americans. Today, diseases of the heart remain the major cause of death in the United States. Recent mortality statistics reveal that in 1990, more than 934,000 Americans died from CHD which is more than died from all the wars during the last century (33). Data from a recent Behavioral Risk Factor Surveillance System survey (6) indicate the percentage of CHD deaths attributable to sedentary lifestyle in the individual state of Alabama in 1988 was 34%. If this risk factor had not been present in Alabamians, it is projected that almost 3000 deaths could have been prevented (6).

Because of the significant impact that exercise has on the ability to directly reduce the risk for several major chronic diseases as well as its ability to catalyze positive indirect changes with respect to other CHD risk factors, Dr. William Foege, former Director of The Centers for Disease Control, suggest that physical activity may provide the "shortcut" that investigators have been seeking for the control of chronic diseases much like immunizations facilitated progress against infectious diseases (16). Accordingly 13 states, including Alabama, are currently promoting physical activity as an integral part of comprehensive cardiovascular disease prevention programs.

Health Promotion Initiatives

The concept of a national plan for improvement of the health of Americans is not new. Healthy People 2000 objectives are built on a public health initiative started during the previous decade called *Promoting Health/Preventing Disease: Objectives for the Nation* (29). This initiative was structured around 226 measurable objectives that were to be achieved during the 10 year period between 1980 and 1990 (17).

A review of the accomplishments from this initiative indicates that significant progress was made in improving health status in a number areas. There were, however, some disturbing exceptions to the overall achievements. Weaknesses in improvement in physical activity and fitness were among the most prominent. Of the 11 physical activity objectives that were to be achieved by the year 1990, only four

were accomplished, mainly in the areas related to improvements in data surveillance and evaluation (8,17). The objectives that were not achieved include those that target risk reduction by altering specific levels of activity among the various age groups.

In light of the strong association between physical activity and optimal health, and given the favorable impact that exercise can have on disease progression and risk reduction, it is no wonder that physical activity was placed as the first priority of the seven health promotion objectives of Healthy People 2000 and was included as a significant component among the chronic diseases risk reduction objectives for the state of Alabama called Healthy Alabama 2000: Health Promotion and Disease Prevention Objectives for the Year 2000 (1).

Current Status of Physical Fitness Goals for the Nation

On April 14, 1992, 20 months after the release of Healthy People 2000, the Public Health Service held its first progress review to determine the progress of the physical activity and fitness objectives and to place them in perspective to the nation's previous 10 year progress in improving physical fitness (10).

The initial two objectives target improvements in "health status" related to chronic diseases/conditions that are linked to lack of physical activity (16). The first objective shown in Fig. 1A is to reduce coronary heart disease deaths from the baseline of 135 per 100,000 recorded in 1987 to 100 per 100,000 by the year 2000 (11). There were 130 deaths in 1988 and 124 in 1989 (20). Whereas the decline is in the right direction and the goal looks promising for being met by the year 2000, slower progress is being met to decrease African American deaths. There were 163 deaths per 100,000 in 1987, 162 in 1988 and 159 in 1989, toward a target of 115 by the year 2000 (20).

The progress towards reducing the percentage of overweight adults age 20 and older to a prevalence of no more than 20% (Figure 1B) is not nearly so favorable. The trend as of 1990 shows a slight increase rather than a reduction. The percentage of overweight adults rose from a baseline of 26% in 1980 to 27% in 1990 (22). The percentage of adult black women did show a slight improvement from 44% in 1980 to 42% in 1990 towards a goal of 25% by the year 2000 (22).

The four objectives that address risk reduction through an increase in physical activity and sound nutritional practices are presented in Figure 2. The first goal proposes to increase to 30% the prevalence of people performing light to moderate activity. The second goal is to increase to 20% the percentage of people performing vigorous activity (11). The data presented in Figure 2A obtained by the Behavioral Risk Factor Surveillance System (2) and the National Health Interview Survey (21) indicates that the prevalence of individuals performing moderate physical activity appears to have decreased rather than increased from 22% in 1985, to 20% recorded among those aged 18 and older in 1990 (Figure 2B) (2,21). More alarming

however, was the report that 26% of American adults 18 and older are completely sedentary, up from the baseline of 24% recorded in 1985 and far from the projected goal of 15% by the year 2000 (11) (Figure 2C).

Not only are Americans apparently reluctant to give up their inactive lifestyle, they are somewhat disinclined to adopt sound dietary practices as well. The goal as shown in Figure 2D is to increase to 50% the proportion of overweight people adhering to sound dietary practices combined with regular exercise to attain an appropriate body weight (11). The percentage of women actually declined from 30% in 1985 to 29% in 1990 and from 25% to 22% among men (21).

Physical Activity and Children

The beginning of this century was evidenced by a marked improvement in the health of American adolescents, but currently the trend appears to be reversing (19). Today's teenagers are in poorer health than their parents were at the comparable age (3,18). It has been reported that as many as 60% of children in America today exhibit at least one modifiable adult risk factor for CHD by the age of 12 (3,34). For example, children today have significantly more fat than children in 1960 (19,25). Similarly the literature indicates an increase of more than 50% in the prevalence of obesity and nearly 100% increase in the prevalence of super-obesity in today's youth (19,30). Because children's risk factor status established early in life may persist into adulthood, good nutrition habits and physical activity patterns based on sound choices must be recognized as cost-effective means for normal growth and development during adolescence and for decreased risk for the development of chronic diseases into adulthood (3,30).

The setting that appears to have the most promise of providing a public health impact is the school because virtually all children can be reached in school, and an existing mechanism is already in place for the facilitation of physical education and health education (18,30). With this considerations in mind, two of the physical fitness goals have been targeted for the school environment. The first of these goals is to increase the daily school physical education participation from 36% to more than 50% of proportion of youths in grades 1-12 engaging in daily school physical education (Figure 3A). The second goal is to increase from 27% to 50% the proportion of physical education class time that students spend in quality physical fitness activities (Figure 3B) (11).

The results of the 1990 Youth Risk Behavior Survey (35) reveal the same disturbing trends recorded earlier with the National Children and Youth Fitness Survey (15). Rather than showing an increase, the percentage of high school students enrolled in physical education classes continued to decline from 1984 to 1990 (Figure 3C) (7). One bright spot in the newer survey however, revealed that even though fewer students were participating in physical education classes, the time devoted during the class time to quality physical activities increased from 27% in 1984 to 33% in 1990 (Figure 3B) (7).

Current Status of Physical Fitness Goals in Alabama

Alabama has only one physical activity and fitness goal as part of Healthy Alabama 2000. This goal is targeted to simply reduce inactivity and increase the proportion of Alabamians who engage regularly in light to moderate activity on a regular basis. Specifically the goal is to increase the proportion of Alabamians aged 13 - 18 to 50% and adults aged 18 and over to 30% who engage regularly, preferably daily, in light to moderate activity for at least 30 minutes a day (1).

An exact determination of progress toward this goal is limited since there has not been an extensive and regular collection of physical fitness data over the past several years for the state of Alabama as there has been for the nation as a whole. It should be pointed out however, the data that has been collected for the state of Alabama has been both revealing and quite disturbing.

The number of Alabamians 18 and over reporting a sedentary lifestyle is greater than the 25% reported for the nation. In the 1991 BRFSS survey as conducted by the Alabama Department of Public Health's Bureau of Health Promotion and Information Surveillance Division (5), 56.6% of Alabamians reported they were sedentary (Figure 4A). Not only is this percentage very high, but the percentage of Alabamians reporting a sedentary lifestyle has remained relatively flattened at 59% over the past 6 years. In addition, the number of adults aged 18 and over who reported engaging in daily, light to moderate activity for 30 minutes was only 8.4% of the state's population (1).

Increasing evidence suggest that light to moderate physical activity, below the level recommended for cardiorespiratory fitness can have significant health benefits (13,28). Even relatively modest increases in activity have been shown to be associated with measurable benefits in persons who have been inactive (12,23,28). In addition, individuals are more likely to comply with light to moderate exercise than more vigorous.

Since a sedentary life-style is the most prevalent and modifiable cardiac risk factor, and given the impact that exercise can have on disease progression, from an optimal health perspective, increasing physical activity seems to be the most advantageous modification that Alabamians can make in risk reduction and enhancing their overall health.

Conclusion

Whereas it may seem difficult to influence a change in the exercise behavior of those who are currently inactive, at the same time it is important to realize that the conversion of such individuals to a more active lifestyle is essential. Motivation of individuals to make a substantial investment of personal time to increased activity

can mean improvements in productivity, reduction of absenteeism, a decreased demand for medical services, and most important, containment of health care cost.

Progress towards attaining the fitness components of the state and national year 2000 objectives appears to be only marginal at best. The challenges are before us. If the goals as set forth in these two health documents are to be met, major changes in our lifestyles will have to take place in the next seven years. A concerted commitment is required with new initiatives, dissolving of previous barriers, intensified and perhaps realigned efforts at many levels and within many sectors. Achievement of the goals will require a collective action among government, business, labor, education and health professionals. Only with the sharing of talents and resources will the goals be met by the year 2000 resulting in a healthier nation and Alabama.

REFERENCES

1. Alabama Department of Public Health. Healthy Alabama 2001: Health promotion & Disease Prevention Objectives for the Year 2000 October 1991
2. Behavioral Risk Factor Surveillance System, Center for Disease Control, Public Health Service. 1990
3. Berenson G., McMahon C., Voors A. Cardiovascular Risk Factors in children: The Early History of Atherosclerosis and Essential Hypertension. New York: Oxford University Press, 1980
4. Baranowski T., Bouchard C., Bar-Or O., Bricker T. Assessment, prevalence, and cardiovascular benefits of physical activity and fitness in youth. Med Sci Sports Exer 24:S237-s247, 1992.
5. Caspersen, J.C. Physical inactivity and coronary heart disease. Phys Sports Med 15:43-44, 1987
6. Center for Disease Control Behavioral Risk Factor Surveillance System 1992 as conducted by the Alabama Department of public Health, Bureau of Health Promotion and Information. Montgomery, Ala. 1991.
7. Centers for Disease Control. Coronary Heart Disease Attributable to Sedentary Lifestyle-Selected States, 1988. 1990. JAMA 261:390 - 1392.
8. Centers for Disease Control. Participation of high school students in school physical education - United States, 1990, MMWR 40:607-615, 1991
9. Centers for Disease Control. Progress towards achieving the national 1990 national objectives for physical fitness and exercise. 1989. MMWR 38:449-453.

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10. Hagberg J., Montain S., Martin W., Ehsani A. Effect of exercise training in 60 - 69 year old persons with essential hypertension. *Amer J Cardiology*. 64: 348-353, 1989
11. Hartley, L.H. The role of exercise in the primary and secondary prevention of atherosclerotic coronary artery disease. in *Exercise and the Heart*, edition 2. N. K Wenger and A.N. Brest. editors. 1985. F. A. Davis Company, Philadelphia
12. Healthy People 2000: National Health Promotion and disease prevention objectives. 1990. Washington, D.C. Government Printing Office, DHHS publication no. (PHS) 90-50212.
13. Hickey, N., Mulcahy, R. and Bourke G. 1975. Study of coronary risk factors related to physical activity in 15,721 men. *Br Med J* 3:507-510.
14. Leon, A. S., Connell J, Jacobs D, and Raurama R. Leisure-time physical activity levels and risk of coronary heart disease and death: The Multiple risk factor intervention trial. *JAMA* 258:2388-2395, 1987
15. Levit KR, Lazenby HC, Letsch SW Cowan C. National health care spending. *Health Aff* 10:177-130, 1991
16. Mason J. A public health service progress report on Healthy People 2000: Physical Activity and Fitness. U.S. Department of Health and Human services. Public Health Service. 1992
17. McGinnis J.M. The public health burden of a sedentary lifestyle. *Med Sci Sports Exer*. 25:(6)supplement, S196-200, 1992
18. McGinnis J.M., Richmond J., Brandt E. Windom R., Mason J. Health progress in the United States. Results of the 1990 Objectives for the nation. *JAMA* 268: 2545-2552
19. McGinnis J. M. Healthy schools 2000: Creating partnerships for the decade. *J Sch Hlth*. 61:292-296, 1991
20. Meredith CN, Dwyer JT. Nutrition and exercise: Effects on adolescent health. *Annu Rev Publ Health* 12:309-333, 1991
21. National Center for Health Statistics. National Vital Statistics System, Center for Disease Control, Public Health Service. 1990

22. National Health Interview Survey, National Center for Health Statistics. National Vital Statistics System, Center for Disease Control, Public Health Service. 1990
23. National Health and Nutrition Examination Survey, National Center for Health Statistics. National Vital Statistics System, Center for Disease Control, Public Health Service. 1990
24. Paffenbarger R., Hyde R., Wing A. Physical activity and physical fitness as determinants of health and longevity. In: Exercise, Fitness, and Health. C. Bouchard, Shephard R., Stephens T., Sutton J., McPherson B. (Eds.). Champaign, IL, Human Kinetics Books 1990
25. Paffenbarger R., Hyde R., Wing A., Lee I. The association of changes in physical -activity level and other lifestyle characteristics with mortality among men. New Eng J Med. 328:538-545, 1993
26. Parcel GS, Simons-Morton BG, O'Hara NM. School promotion of healthful diet and exercise behavior. An integration of organizational change and social learning theory interventions. J Sch health 57(4) 150-156, 1987
27. Patrick D, Erickson P. Health Status and Health Policy. Quality of Life in Health Care Evaluation and Resource Allocation. Oxford University Press. New York, pp 1-26. 1993.
28. Pekkanen J. , Marti B., Nissinen A., Tuomilehto J., Punstar S., Karvonen M. Reduction of premature mortality by high physical activity: a 20-year follow-up of middle-aged Finnish men. Lancet 1:1473-1477, 1987
29. Powel K., Caspersen C., Koplan J., Ford E. Physical activity and chronic diseases. Am J Clin Nutr 49:999-1006, 1989
30. Promoting Health/ Preventing Disease: Objectives for the Nation. Washington, D.C. US Department of Health and Human Services, Public Health Service, 1980.
31. Sallis JF, Simons-Morton BG, Stone EF, Corbin CB. Determinants of physical activity and interventions in youth. Med Sci Sports Exer 24 (6) S248-S255, 1992
32. Simons-Morton B., Parcel G., Baranowski T., Forthofer R., O'Hara N. Promoting healthful diet and physical activity among children: Results of a school-based intervention study. Am j Public Health 81:986-991, 1991

Physical Fitness and Healthy People 2000

33. Siscovick D., LaPorte R., Newman J. The disease-specific benefits and risks of physical activity and exercise. *Public Health Rep* 100:180-188, 1985
34. U.S. Bureau of Census, *Statistical Abstract of the United States: 1991 (11th Edition)* Washington, D.C. 1991
35. Williams C., Carter B., Wynder E. Prevalence of selected cardiovascular and cancer risk factors in a pediatric population: the "Know your Body" Project, New York. *Pre Med* 10:235-250, 1981
36. Youth Risk Behavior Survey, National Center for Health Statistics. National Vital Statistics System, Center for Disease Control, Public Health Service. 1990

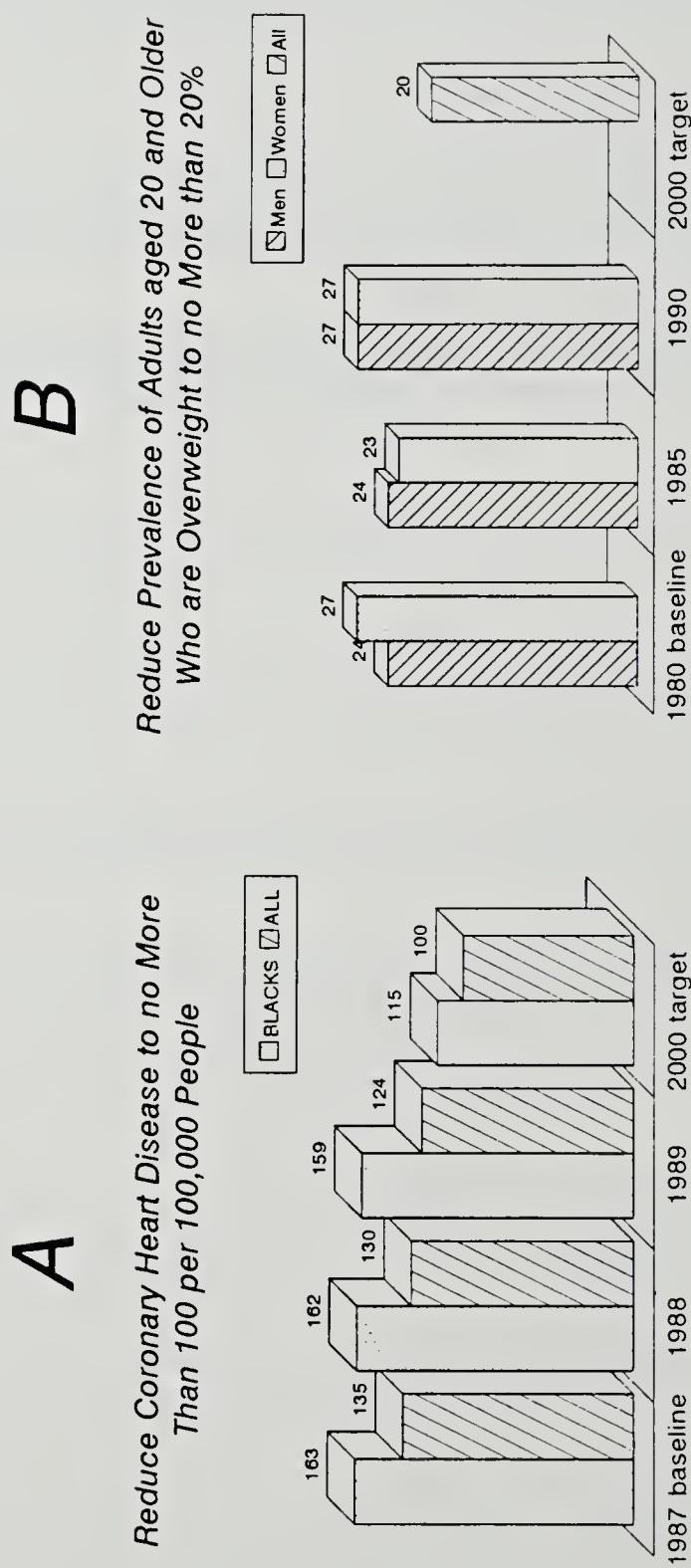
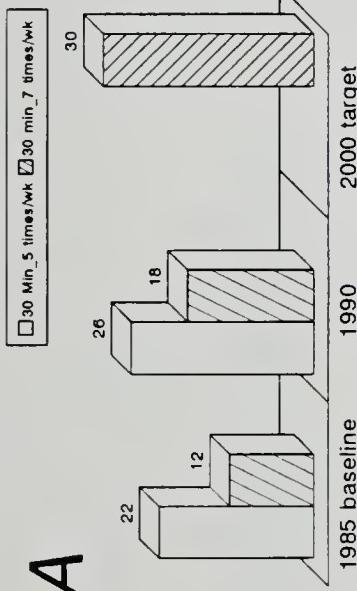


Figure 1. Year 2000 goals for improving health status related to chronic diseases that are linked to physical inactivity.

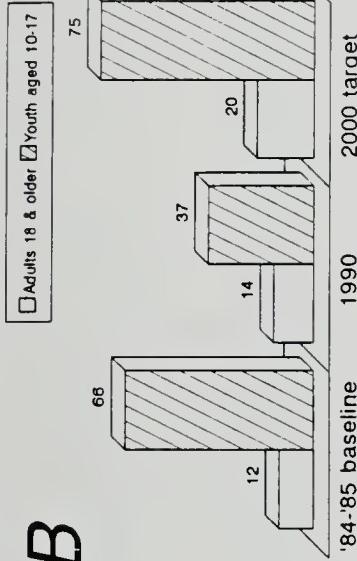
Physical Fitness and Healthy People 2000

*Increase Percentages of People aged 6 and Older Who Engage in Light to Moderate Exercise**



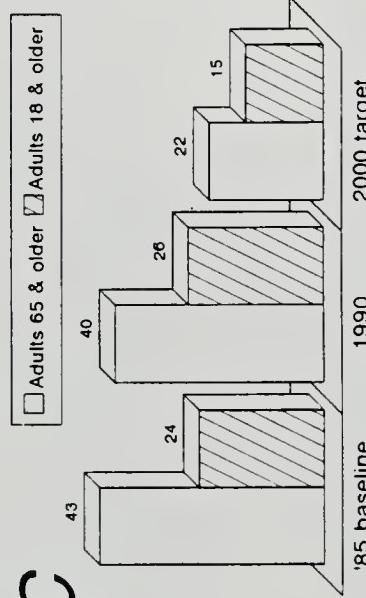
*Sustained, rhythmic movements at a level of 60% of max HR

*Increase Percentages of People aged 18 and Older Who Engage in Vigorous Exercise **



*Sustained, rhythmic movements at a level $\geq 60\%$ of max HR for at least 20 minutes per occasion, at least 3 times/wk

Reduce Percentages of People aged 6 and Older Who Engage in No Leisure Time Exercise



Increase Percentage of Overweight Persons Who Have Adopted Sound Dietary Practices plus Exercise

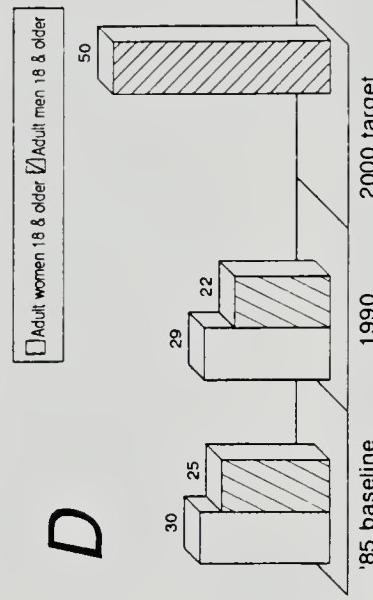


Figure 2. Year 2000 goals related to coronary heart disease risk reduction through an increase in physical inactivity and sound nutritional practices.

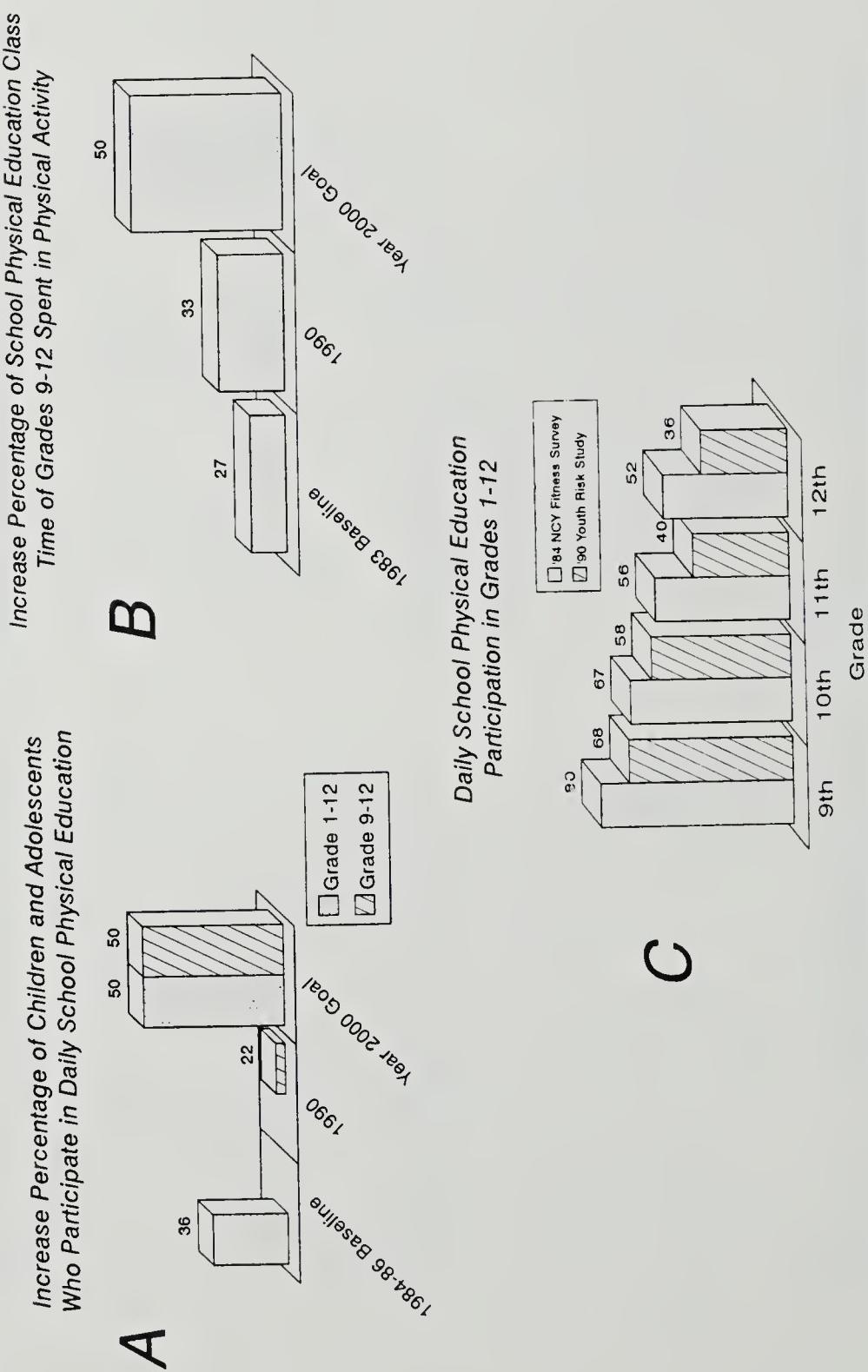
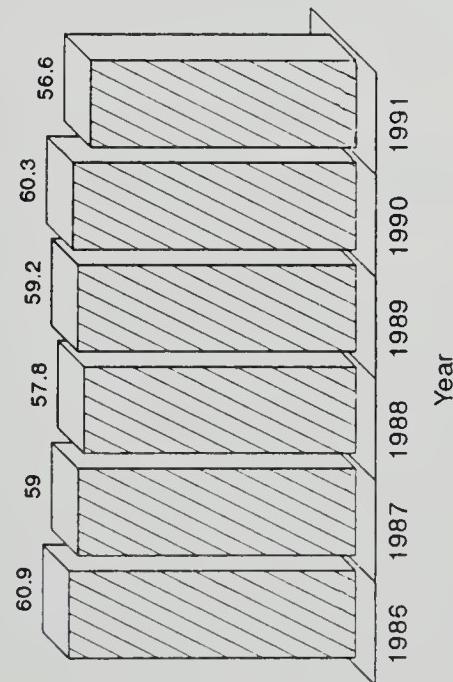


Figure 3. Year 2000 goals related to coronary heart disease reduction through an increase in physical activity in a school setting.

A

*Percentage of Alabamians 18 and
Older Reporting a Sedentary Lifestyle*

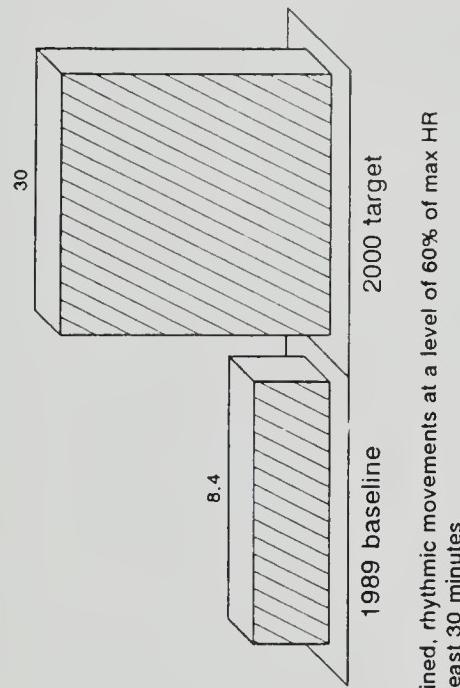


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B

Physical Fitness and Healthy People 2000

*Increase Percentage of Alabamians aged 18 and Older Who
Engage Regularly, Preferably Daily, in Light to Moderate Exercise**



*Sustained, rhythmic movements at a level of 60% of max HR
for at least 30 minutes

Figure 4. Status of physical activity and the Year 2000 physical activity goal for the state of Alabama.

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COVER PHOTOGRAPH: The cover photograph is a view of Bogue Chitto Creek taken by Steven M. McCarroll adjacent to the railroad crossing over the Creek in Dallas County, Alabama. Shown is a site from which Pleistocene and Late Cretaceous aged vertebrates were obtained by sifting sediments.

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**LONG-TERM EFFECTS OF EXERCISE ON TRANSPLANTABLE
NEOPLASTIC TISSUE GROWTH IN RATS¹**

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ABSTRACT

The long-term effects of exercise upon: 1) frequency and incidence of neoplastic lesions by preselected categories, 2) number of neoplasms by morphologic type, anatomic site and weight, 3) body and selected organ weights and 4) survival experience was determined in rats receiving a transplantable pancreatic carcinoma. Seventy-two, Lewis strain rats were assigned to either an exercise or sedentary group. Exercise animals received thrice weekly aerobic training on a motorized treadmill. The pre-inoculation period was 482 days. Pre-inoculation exercise duration was 60 minutes per bout and post-inoculation was 60 minutes for the first 20 weeks, 30 minutes for the next 9 weeks and 15 minutes thereafter. Body and relative and absolute pancreas, liver, kidney, and spleen weights were statistically treated through two-way ANOVA with initial body weight as a covariate. The frequency and incidence of neoplastic lesions were measured by a visual scoring procedure. Kolmogorov-Smirnov test, T-test, Chi-square and Mann-Whitney U test were utilized for statistical analysis. In addition the Lee-Desu D was employed to determine significant differences between survival curves. The exercise subjects demonstrated

¹Manuscript received 9 June 1993; accepted 4 January 1994.

a significant greater frequency and incidence of multiple anatomic sites involved with neoplastic lesions than sedentary subjects. The exercise subjects had a significantly greater total number of discrete, fused, both discrete and fused neoplasms and different anatomic sites of fused neoplasms than sedentary controls. There were no significant differences between the groups in body weights at necropsy. Exercise subjects had significantly heavier relative liver weights than sedentary controls. Results indicated no significant differences between groups in survival rates. Exercise's purported beneficial role in decreasing the frequency and incidence of neoplasms, limiting the number of neoplasms by morphologic type, anatomic site and weight, maintaining body and organ weights and in prolonging the survival experience in tumor-bearing rats was not demonstrated.

Introduction

The research concerning the effects of physical exercise in enhancing immunocompetence and resistance to tumor growth is ambiguous and conflicting. Several researchers, [1-3] have shown exercise to increase susceptibility to disease and reduce immune responsiveness in humans. Several animal studies [4-7] failed to demonstrate beneficial effects, where other studies [8-9] have shown regular aerobic exercise to improve immunologic competence and decrease susceptibility to disease. Research evidence by Hanson et al. [8] and Hedfors et al. [9] suggest that one of the ways in which exercise provides resistance to tumor growth may be by stimulating an increase in natural killer cells and cytotoxic T-lymphocytes, thereby enhancing cellular immunity and host defense capacity against proliferating tumor cells.

Purpose

The purpose of this study was to investigate the long-term pathophysiologic effects of exercise upon frequency and incidence of neoplastic lesions in preselected categories, number of neoplasms by morphologic type, anatomic site and weight, selected body and organ weights, and survival experience of rats receiving a transplantable pancreatic carcinoma.

Materials and Methods

Treatment and Management of Subjects. Seventy-two male, 60 day old rats of the Lewis strain were randomly assigned to one of two experimental groups: exercise (N=36) or sedentary (N=36). The experimental cell sizes were a function of the number of running lanes available and the labor-intensive nature of the exercise regimen. The subjects were housed in identical environmental conditions: temperature 21.1°C, humidity 50%, and 12L:12D. Food and water were offered ad libitum. The subjects were fed a diet composed of standard rat food pellets (Purina Rat Chow).

Long-Term Effects of Exercise

Sedentary subjects were assigned to standard rat cages (20.3 cm X 25.4 cm X 45.7 cm) and remained limited in physical movement throughout the study. The exercise protocol and intensity were patterned after previous research by Deuster [10] and Thompson [11]. A motor-driven treadmill with a belt speed 1.2 km/h was used to provide the physical conditioning. To ensure that the belt speed was uniform throughout course of the experiment, the treadmill was recalibrated once a month or as necessary. Exercise subjects received one week of training on the treadmill prior to the exercise treatment period to ensure familiarity and proficiency. Initially, exercise subjects received 1 hour of aerobic conditioning on a thrice weekly basis with at least one day of rest between each session. The pre-inoculation exercise regimen was 325 days in duration and commenced when subjects were about 74 days of age. Post-inoculation exercise bouts were 60 minutes in length for a time period of 20 weeks, whereafter a 30 minute regimen was adopted. After two-hundred days of post-inoculation exercise a 15 minute regimen was adopted. There were 469 total days available for the post-inoculation exercise regimen and the total amount of pre- and post-inoculation exercise conditioning possible, excluding familiarity training, was 794 days.

Body weights were measured every third day. If at any time during the 325 day pre-inoculation exercise conditioning period, the subjects became moribund or lost more than 15% of their maximum attained weight, then the subjects were eliminated from the study. Experience had shown that these subjects would not live. After transplantation of tumor cells, all subjects continued to receive physical conditioning until such time that the onset of hypophagia or states of weakness and fatigue were observed, or the subjects were moribund. The subjects were then forced to retire from the exercise treatment and were returned permanently to their cages. In some cases, change in motor performance on the exercise treadmill came about rather abruptly, occurring often about 1-7 days before death. The study was terminated after 794 days, when all subjects had died. The last subject to die was 868 days old.

Tumor Cells and Challenge Dose. Tumor cells used for challenge were obtained from an established tumor repository (NCI-Frederick Cancer Research Facility, Frederick, MD). All rats received a suspension of minced tumor cells. The tumor used was pancreatic carcinoma DSL62-38 and was originally induced by azaserine in Lewis rats. Tumor lines were titrated in syngeneic rats and the challenge dose chosen for tumor implantation was that which grew in approximately 60% of the control rats. Implantation of tumor cells occurred after 325 days of the experimental regimen, when the subjects were 399 days old.

Preparation and Transplantation of Tumor Brei. An 18-gauge needle was utilized for intraperitoneal injections of tumor brei. The donor animals were sacrificed and immersed in a 0.1% Zephiran (benzalkonium chloride) solution prior to transplantation. Tumor tissue was excised, stripped of normal fascia, and debrided

of any necrotic tissue prior to mincing with scissors. Small solid pieces of tumor tissue were then filtered through a sterile, 40 gauge steel mesh, by rinsing with an ice-cold (4°C) Dulbecco's modified Eagle's medium supplemented with 10% fetal bovine serum. The tumor cells were briefly maintained in a sterile beaker surrounded by an ice bath. The dissociated tumor cells were counted by hemocytometer and a sufficient amount of sterile, balanced salt solution was then added to the beaker, so as to yield a 5 to 10×10^6 cells/ml of cell suspension. Viability was determined by the utilization of the trypan blue dye exclusion test. A tumor cell suspension of 1×10^6 cells, as determined by earlier titrations in control rats, was utilized as the challenge dose. A maximum of 30 minutes transplantation time was allowed.

Measurement of Body and Organ Weights. Body weight at necropsy (BWN) was measured by utilization of an electronic scale. At necropsy the entire pancreas, liver, kidneys, spleen were excised and weighed on an electronic scale. Measures of the absolute weight, in grams, of the pancreas (APANWT), liver (ALIVWT), kidneys (AKIDWT), and spleen (ASPLWT) were obtained by using an electronic scale. Relative weight measures of the pancreas (RPANWT), liver (RLIVWT), kidneys (RKIDWT), and spleen (RSPLWT) were calculated by dividing the absolute organ weight by the BWN.

Necropsy. Consequent to visual examination for gross pathological changes in any body organ or tissue, suspected tissue(s) were excised and the morphologic characteristics, anatomic location(s) selected weight(s) were recorded.

Measurement of the Number of Neoplasms by Morphologic Type, Anatomic Site and Weight. The specific criteria utilized for determination of the number of neoplasms, morphologic types, anatomic sites and weights are as follows:

Number of Neoplasms: the numerical totals for seven categories of neoplastic lesions are: (1) total number of rats with tumors (TNR); (2) total number of discrete tumors (TND); (3) total number of fused tumor masses (TNF); (4) collective total number of discrete and fused tumor masses (CTNDF); (5) total number of different anatomic sites with discrete tumors (TNDASD); (6) total number of different anatomic sites with fused tumors (TNDASF); (7) total weight of discrete tumors (TWD).

Morphologic types: the intraperitoneal route of administration of tumor cells, will in some cases, result in multiple organ masses fused by the growth of neoplastic tissue. Morphologically, these fused masses are characterized as being composed of multiple organs or tissue types, while discrete masses are considered to affect only a single body organ or primarily one tissue type.

Anatomic sites: the specific anatomic location(s) of grossly visible and discrete neoplastic lesions affecting any body organs or tissues, excluding the pancreas, liver, kidney, and spleen, are recorded prior to weighing.

Long-Term Effects of Exercise

Weights: neoplastic lesion tissue of the fused type is weighed exclusive of the organs involved. Along these same lines, some organs will have to be dissected free of fused neoplastic lesion masses, in which they had become embedded, before individual organ weights can be ascertained.

Measurement of Neoplasms by Lesion Category. Testing procedures derived from previous studies [12, 13, 14] were used to detect and subjectively measure the frequency and incidence of neoplastic lesions. A subjective scale consisting of three categories of neoplastic lesions was used to measure both the frequency and incidence of neoplasms. The categories were: 1=minimum of one lesion; 2=multiple lesions of the same anatomic site (i.e., in one subject's liver, 4 lesions); and 3=multiple anatomic sites involved with the same or different lesion(s) (i.e., in one subject a single large lesion mass enveloping the pancreas, spleen and mesentery proper or in one subject's kidney(s), teste(s) and retroperitoneum, each organ with one or more lesions, respectively). The incidence of neoplastic lesions was determined by scoring each animal once in the category of the highest grade lesion found. In an effort to measure the multiplicity or presence of lesions of more than one category in a single subject, the frequency of lesions was determined as well, by scoring each animal, in each lesion category, every time applicable. A blind coding procedure was utilized and each specimen was graded twice, once by the investigator and once by the coinvestigator. The ranked scores were then averaged by each subject. Finally, the vasa deferentia were examined for confirmation of the vasectomy status of each specimen.

Statistical Analysis. Data from BWN and organ weights were statistically treated through two-way analysis of variance with initial body weight as a covariate. Multiple comparisons of group means were performed by utilization of the Duncan method as already reported [15]. In addition, the Kolomogrov-Smirnov two-sample statistical test was utilized to further determine any significant differences between experimental groups in organ weights. Since a significant difference in an organ weight between two experimental groups may be ascribed to a higher incidence of organs demonstrating preneoplastic lesions or gross changes suspected of being tumors; statistical examination of the organ weights in the upper portion of the sample distribution of each of the six experimental groups was warranted. The Kolomogrov-Smirnov procedure was utilized, in a manner similar to Anderson [12], to establish the optimal cut-off point for ascertaining significant differences in organ weights. The number of organ weights equal to or greater than the derived cut-off weight were summed for each group.

The frequency of neoplastic lesions by category were analyzed by the Student's t-test (pooled variance estimate) and the incidence data of the same by utilizing Chi-square test with Yates correction for continuity. Numerical neoplastic lesion data by morphologic type, anatomic site and weight were analyzed by the nonparametric Mann-Whitney U test and expressed as a probability value.

Two methods of survival analyses were performed. These analysis procedures were provided by the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL. Life Tables, based on the methods of Berkson [16], produced cumulative survival rates for each of the treatment groups. Secondly, pairwise comparisons of the survival experience for the cases in the experimental and control groups was performed using the methods of Lee [17]. For each of these two methods, two survival analyses were performed. One included all the rats in each group, the other included only those rats which developed at least one neoplastic lesion.

Results

Body and Organ Weight. There were no statistically significant differences in body weight between the two experimental groups at the commencement of the study. The RLIVWT mean for the exercise subjects (group 1; 28.85 ± 2.12) was significantly higher than the mean of the sedentary subjects (group 2; 26.70 ± 1.53). Analysis using the Kolmogrov-Smirnov statistical test found that more exercise rats than sedentary (67% versus 17%; $P < 0.02$) had heavier livers, relative to their body weights (sum of organ weights > 27.57 gm cutoffs).

Frequency and Incidence of Neoplasms By Lesion Category. The sedentary (group 2) had an frequency of neoplastic lesions of multiple anatomic sites that was significantly lower than that found among exercise subjects (group 1; $p < 0.01$). Similarly, the incidence of multiple anatomic sites involved with lesions among sedentary controls (group 2) was significantly lower than that found for the exercise subjects (group 1; $p = 0.01$).

Number of Neoplasms by Morphologic Type, Anatomic Site, Weight and Histology. The numerical neoplastic lesion values for morphologic type, anatomic site and weight of the two experimental groups are presented in Table 5. Differences in the numerical lesion values were analyzed for significance using the Mann-Whitney U test. There were significant differences between the experimental groups in TND, TNF, CTNDF, and TNDASF. Data analysis by the Mann-Whitney U test of measurements of TNR, TNDASD, and TWD indicated no significant differences between groups.

The exercise subjects (group 1) had a significantly greater TND, TNF, CTNDF than did the sedentary controls (group 2; $p < 0.02$). Similarly, a comparison between these groups for the TNDASF found the exercise subjects to have significantly more fused tumor masses ($p < 0.01$).

Survival Experience. Post-inoculation survival ranged from 41 to 469 days with a twenty-fifth percentile of 125 days, a fiftieth percentile of 229 days and a seventy-fifth percentile of 358 days. The mean survival experience was 238 days. Utilization of the Lee-Desu D statistic revealed no significant difference in the survival curves for the two treatment groups. Further pairwise comparisons for equality of the survival curves indicated no significant differences.

Long-Term Effects of Exercise

Table 1. Mean values of body and organ weight at necropsy

Experimental Groups		
	1 N=18	2 N=27
Site		
BODY WEIGHT	396.2 ± 23.5	401.7 ± 16.8
ABSOLUTE WEIGHTS		
Pancreas	2.62 ± 0.30	2.88 ± 0.17
Liver	11.03 ± 0.68	10.72 ± 0.86
Kidney	3.75 ± 1.03	3.94 ± 1.22
Spleen	0.91 ± 0.18	1.41 ± 0.44
RELATIVE WEIGHTS		
Pancreas	6.70 ± 0.64	7.16 ± 0.29
Liver	28.85 ± 2.12	26.70 ± 1.53
Kidney	10.02 ± 3.05	11.99 ± 5.25
Spleen	2.23 ± 0.38	3.37 ± 0.97

Table 2. Frequency^a of neoplastic lesions in each experimental group by lesion category.

Category of lesion	Experimental Groups ^b	
	1 (N=18)	2 (N=27)
Minimum of one lesion	17	22
Multiple lesions (same anatomic site)	8	8
Multiple anatomic sites ^c	12	8

a Frequency is determined by scoring each animal, in each lesion category, every time applicable.

b 1 = exercise and 2 = sedentary.

c Significant difference at 0.01 level utilizing T-test (pooled variance estimate).

Long-Term Effects of Exercise

Table 3. Incidence^a of neoplastic lesions in each experimental group by lesion category.

Experimental groups ^b		
	1 (N=18)	2 (N=27)
Category of lesion		
Number of tumor-bearing animals	17(94) ^c	22(81)
Minimum of one lesion	3(17)	11(41)
Multiple lesions (same anatomic site)	2(11)	3(11)
Multiple anatomic sites ^d	12(67)	8(30)

a Incidences are based on scoring each animal once in the category of the most advanced lesion. Multiple anatomic sites is the most advanced lesion category.

b 1 = exercise and 2 = sedentary.

c Numbers in parentheses are percentages.

d Significant difference at 0.01 level, utilizing Chi-square test with the Yates' correction for continuity.

Table 4. Number of Neoplasms by Morphologic Type, Anatomic Site and Weight

Experimental Groups ^a	1	2
No. of rats	18	27
Total No. of rats with tumors (discrete/fused)	17 (15/0)	22 (22/0)
Total No.(mean) of discrete tumors ^{b,d}	37 (2.1)	36 (1.3)
Total No.(mean) of fused tumor masses ^{b,d}	3 (0.2)	0 (0)
Total No.(mean) of discrete and fused tumor masses ^e	40 (2.2)	36 (1.3)
Total No. of different anatomic sites with tumors (discrete/fused) ^d	26/3 ^c	24/0
Total (mean) weight of discrete tumors (gm)	377.1 (21.0)	260.0 (9.6)

Long-Term Effects of Exercise

- 1 = exercise subjects and 2 = sedentary controls.
- Discrete = a tumor of a single body organ or primarily one tissue type; fused = a tumor mass composed of multiple organs or tissue types.
- one fused mass in one subject involving: testes, epididymus, seminal vesicles, and testes, mesentery proper and retroperitoneum and in another subject, one fused mass involving: esophagus, kidney, liver, pancreas and spleen.
- Significant differences at the 0.02 level using Mann-Whitney U test, corrected for ties, between groups 1 and 2 for total number of discrete tumors, total number of fused tumors and for number of different anatomic sites with fused tumor masses.
- Significant difference at 0.01 level between groups 1 and 2 for a collective total number (mean) of discrete and fused tumor masses.

Discussion

The results of this study partially support the hypothesis that exercise may exert pathophysiologic effects on the growth of transplantable neoplastic tissue. The observation that exercise subjects (group 1) had a greater frequency and higher incidence of neoplastic lesions, found in multiple anatomic sites, as compared to sedentary subjects (group 2) would appear to indicate that exercise may accelerate transplantable neoplastic tissue growth. Similarly supportive of such a detrimental effect was the finding of a greater TND, TNF, CTNDF, TNDASF in exercise subjects as compared to sedentary controls. These findings were in agreement with an investigation by Thompson [11], who while using rats, noted that treadmill exercise increased the frequency and incidence of chemically-induced cancer. In contrast, earlier rat and mouse studies [18-23] provided evidence of exercise-induced inhibition of tumor growth, despite considerably shorter experimental time frames. These studies reported that physical exercise either inhibited the growth of transplantable tumors or the incidence of chemically-induced or spontaneous tumors. Similarly conflicting, are more recent investigations [10, 24-29] that have shown prolonged endurance exercise to reduce tumor size and incidence in mice and rats.

The results regarding the lack of significance of BWN were unexpected as the mean necropsy weight of the exercise subjects (group 1) was no different than that of sedentary controls (group 2). Exercise subjects (group 1) were able to preserve their body mass as well as sedentary controls (group 2). Any effects on tumor host metabolism by exercise may be related to these findings, but do not explain why the BWN of the exercise subjects (group 1) were not significantly heavier than that of sedentary controls (group 2). Longnecker [30] reported the growth of intraperitoneal transplants of pancreatic tumor tissue in the small bowel mesentery, omentum, retroperitoneum, and in the region of the pancreas in Wistar/Lewis rats. In addition,

these researchers reported that preneoplastic lesions appeared to be metastatic in the livers and spleens of their subjects, with large intraperitoneal masses also observed at necropsy. In the current study, most of the the large intraperitoneal neoplastic tissue masses were categorized as multiple anatomic sites involved with neoplastic lesions. The exercise group demonstrated a significant greater frequency and incidence of neoplastic lesions involving multiple anatomic sites than did the sedentary group. Similarly, the exercise subjects (group 1) had a greater number of TND, TNF, CTNDF, and TNDASF as compared to the sedentary subjects (group 2). However, despite these significant quantitative and qualitative differences in neoplastic lesions, TWD differences between the exercise and sedentary groups were not found to be statistically different. Usually, tumor-bearers gain weight when the tumor grows large enough, although the carcass invariably loses weight [31]. In the present study, the reasons for the lack of BWN differences between the exercise subjects (group 1) and the sedentary subjects (group 2) seems inconsistent with previous research [31]. It is unclear as to why the TWDs were not significantly heavier in the exercise subjects (group 1) as compared to the sedentary controls (group 2).

In the past neoplastic growth has been used as an indicator of the effects of stress on immunocompetence. Promotion of experimental tumor growth as a consequence of stress has been noted [32-33]. Exercise-induced stress has been shown to produce increased plasma concentrations of adrenal corticocoids with consequent impairments to cell-mediated and humoral immunity [34]. Another study reported an increase in tumor frequency and progression among stressed rodent and murine models [32]. Ferry [7] found chronic, treadmill-exercise to induce immunomodulations in rats and speculated that the impairment of some measures of cell-mediated immunity were initiated by the release of cortico-steroids. This may be possible explanation for the failure of exercise to exert any beneficial effect(s) on the growth of transplanted neoplastic tissue in rats.

The increase in RLIVWT in the exercise subjects (group 1) as compared to the sedentary subjects (group 2) was accompanied by large standard errors indicating that organ weights varied considerably within these groups. Extrapolation of the findings of Woustersen [14] suggest that this variability may be due to a gross changes suspected of being tumor.

The survival experience was not significantly different in any of the two groups within the 807 day experimental time frame. Significant differences in mortality among the experimental groups could have affected the overall neoplastic lesion incidence.

Conclusion

In conclusion, exercise's beneficial role in decreasing the frequency and incidence of neoplasms, limiting the number of neoplasms by morphologic type, anatomic site

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and weight, maintaining body and organ weights and in prolonging the survival experience in tumor-bearing rats was not demonstrated. Considering that recent animal research has provided some evidence of a possible link between exercise and selected cancers, the present study should provide impetus for continued longitudinal studies of potential risks.

References

1. F. Blecha and H. C. Minocha. Suppressed lymphocyte blastogenic responses and enhanced in vitro growth of infectious bovine rhinotracheitis virus in stressed feeder calves. *Am. J. Vet. Res.* 44: 2145-2148 (1983).
2. M. P. Reyes and A. M. Lerner. Interferon and neutralizing antibody in sera of exercised mice with coxsackievirus B-3 myocarditis. *Proc. Soc. Exp. Biol. Med.* 151: 333-338 (1976).
3. B. Gatmaitan, J. L. Chason and A. M. Lerner. Augmentation of the virulence of murine coxsackievirus B-3 cardiomyopathy by exercise. *J. Exp. Med.* 131: 1121-1124 (1970).
4. A. E. Cabinian, R. J. Kiel, F. Smith, K. L. Ho, R. Khatib and M. P. Reyes. Modification of exercise-aggravated coxsackievirus B-3 murine myocarditis by T lymphocyte suppression in an inbred model. *J. Lab. Clin. Med.* 115: 454-462 (1990).
5. J. R. Simpson and L. Hoffman-Goetz. Exercise stress and murine natural killer cell function. *Proc. Soc. Exp. Biol. Med.* 195: 129-135 (1990).
6. M. A. Pahlavani, T. H. Cheung, J. A. Chesky and A. Richardson. Influence of exercise on the immune function of rats of various ages. *J. Appl. Physiol.* 64: 1997-2001 (1988).
7. A. Ferry, B. Weill and M. Rieu. Immunomodulations induced in rats by exercise on a treadmill. *J. Appl. Physiol.* 69: 1912-1915 (1990).
8. P. G. Hanson and D. K. Flaherty. Immunologic responses to training in conditioned runners. *Clin. Sci.* 60: 225-228 (1981).
9. E. Hedfors, G. Holm and B. Ohnell. Variations in blood lymphocytes during work studied by cell surface markers, DNA synthesis and cytotoxicity. *Clin. Exp. Immunol.* 24: 328-335 (1976).
10. P. A. Deuster, S. D. Morrison, R. A. Ahrens. Endurance exercise modifies cachexia of tumor growth in rats. *Med. Sci. Sports Exerc.* 17: 385-392 (1985).

11. H. J. Thompson, A. M. Ronan, K. A. Ritacco, A. R. Tagliaferro and L. D. Meeker. Effect of exercise on induction of mammary carcinogenesis. *Cancer Res.* 48: 2720-2723 (1988).
12. D. J. Anderson, N. J. Alexander, D. L. Fulgham, and J. L. Palotay. Spontaneous tumors in long-term vasectomized mice: increased incidence and association with antisperm immunity. *Am. J. Pathol.* 111: 129-139 (1983).
13. T. J. Curphey, E. T. Kuhlmann, B. D. Roebuck, D. S. Longnecker. Inhibition of pancreatic and liver carcinogenesis in rats by retinoid-and selenium-supplemented diets. *Pancreas* 3: 36-40 (1988).
14. R. A. Woutersen, A. van Garderen-Hoetmer, J. Bax and E. Scherer E. Modulation of dietary fat-promoted pancreatic carcinogenesis in rats and hamsters by chronic coffee ingestion. *Carcinogenesis* 10: 311-316 (1989).
15. D. B. Duncan. Multiple range tests for correlated and heteroscedastic means. *Biometrics* 13: 164-174 (1957).
16. J. Berkson and R. Gage. Calculation of survival rates for cancer. *Proc. Mayo Clinic* 25: 270-274 (1950).
17. E. Lee, M. Desu. A computer program for comparing K samples with right-censored data. *Computer Progs. Biomed.* 2: 21-35 (1972).
18. S. A. Hoffman, K.E. Paschkis, D.A. DeBias, A. Cantarow and T. L. Williams. The influence of exercise on the tumor growth of transplanted rat tumors. *Cancer Res.* 22: 597-599 (1962).
19. O. Muhlbock. Influence of environment on the incidence of mammary tumors in mice. *Acta-Unio. Int. Contra Cancrum* 7: 351-353 (1951).
20. H. A. Rashkis. Systemic stress as an inhibitor of experimental tumours in Swiss mice. *Science* 116: 169-171 (1952).
21. H. P. Rusch and M. S. Kline. The effect of exercise on the growth of a mouse tumor. *Cancer Res.* 14: 116-118 (1944).
22. W. S. Bullough. The effects of high and low temperature on the epidermal mitotic activity of the adult male mouse, *Mus musculus*. *J. Exp. Biol.* 26: 76-81 (1949).
23. C. Moore, P. W. Tittle. Muscle activity, body fat and induced rat mammary tumors. *Surgery* 73: 329-332 (1973).

Long-Term Effects of Exercise

24. H. W. Lane, P. Teer, R. E. Keith, M. T. White, S. Strahan. Reduced energy intake and moderate exercise reduce mammary tumor incidence in virgin female BALB/c mice treated with 7,12-dimethylbenz(a)anthracene. *J. Nutr.* 21: 1883-8 (1991).
25. P. L. Daneryd, L. R. Hafstrom and I. H. Karlberg. Effects of spontaneous physical exercise on experimental cancer anorexia and cachexia. *Eur. J. Cancer* 26: 1083-1088 (1990).
26. P. A. Deuster. Effect of exercise on muscle turnover in cancer cachexia. College Park, MD: University of Maryland; Dissertation, 1982.
27. G. deRosa and N. R. Suarez. Effect of exercise on tumor growth and body composition of the host. *Fed. Proc.* 3: 1118, (1980).
28. R. A. Good and G. Fernandes. Enhancement of immunologic function and resistance to tumor growth in BALB/c mice by exercise. *Fed. Proc.* 40: 1040 (1980).
29. R. C. LaBarba. Experiential and environmental factors in cancer: a review of research with animals. *Psychosom. Med.* 32: 259-276 (1970).
30. D. S. Longnecker, H. S. Lilja, J. French, E. Kuhlmann and W. Noll. Transplantation of azaserine-induced carcinomas of pancreas in rats. *Cancer Letters* 7: 197-202 (1979).
31. G. Costa, and J. F. Holland. Effects of Krebs-2 carcinoma on the lipid metabolism of male Swiss mice. *Cancer Res.* 22: 1081-1083 (1962).
32. V. Riley. Psychoneuroendocrine influences on immunocompetence and neoplasia. *Science* 212: 1100-1109 (1981).
33. L.S. Sklar and H. Anisman. Stress and coping factors influences tumor growth. *Science* 513-515 (1979).
34. F. S. Bridges and L.E. Thomas. The immunomodulatory effect of measured physical exercise: implications for eustress and the wellness model. *LAHPERD J.* 49: 37 (1987).

ADDITIONAL PLEISTOCENE MAMMALS FROM BOGUE
CHITTO CREEK, DALLAS COUNTY, ALABAMA¹

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Abstract

Collections of Pleistocene vertebrate fossils from Bogue Chitto Creek, located in the coastal plain of Alabama in Dallas County yielded 14 taxa of mammals not previously known from these deposits: *Holmesina septentrionalis*, *Dasypus bellus*, *Megalonyx jeffersonii*, *Glossotherium harlani*, *Vulpes vulpes*, Carnivora indeterminate, *Castoroides ohioensis*, *Castor canadensis*, *Ondatra zibethicus*, cf. *Lepus* sp., *Equus* sp., *Tapirus veroensis*, *Odocoileus virginianus* and Artiodactyla indeterminate. Previously, only *Elephas imperator*, *Mammut americanum*, and *Equus leidyi* had been reported from these deposits. Based on these additional taxa, the age of these deposits, previously thought to be Aftonian, is here revised to the Rancholabrean. The taxa reported here indicate that during the time of deposition winter conditions were no cooler than those at present. In addition, habitat including forests, wetlands and a significant amount of grassland was present.

Introduction

In the summer of 1985, the authors began collecting vertebrate fossils from an unnamed Pleistocene alluvium along Bogue Chitto Creek, in Dallas County, Alabama (Figure one). Hay (1923) reported *Elephas imperator*, *Mammut americanum* and *Equus leidyi* from Bogue Chitto Creek and it was our hope that a more diverse fauna could be collected. Collection efforts yielded a total of 15 taxa: *Holmesina septentrionalis*, *Dasypus bellus*, *Megalonyx jeffersonii*, *Glossotherium harlani*, *Vulpes vulpes*, Carnivora indeterminate, *Castoroides ohioensis*, *Castor canadensis*, *Ondatra zibethicus*, *Lepus* sp., *Equus* sp., *Tapirus veroensis*, *Odocoileus virginianus*, Artiodactyla indeterminate and *Mammut americanum*. In addition, numerous unidentified specimens were found. All specimens have been catalogued in the collection of the Auburn University Museum of Paleontology (AUMP).

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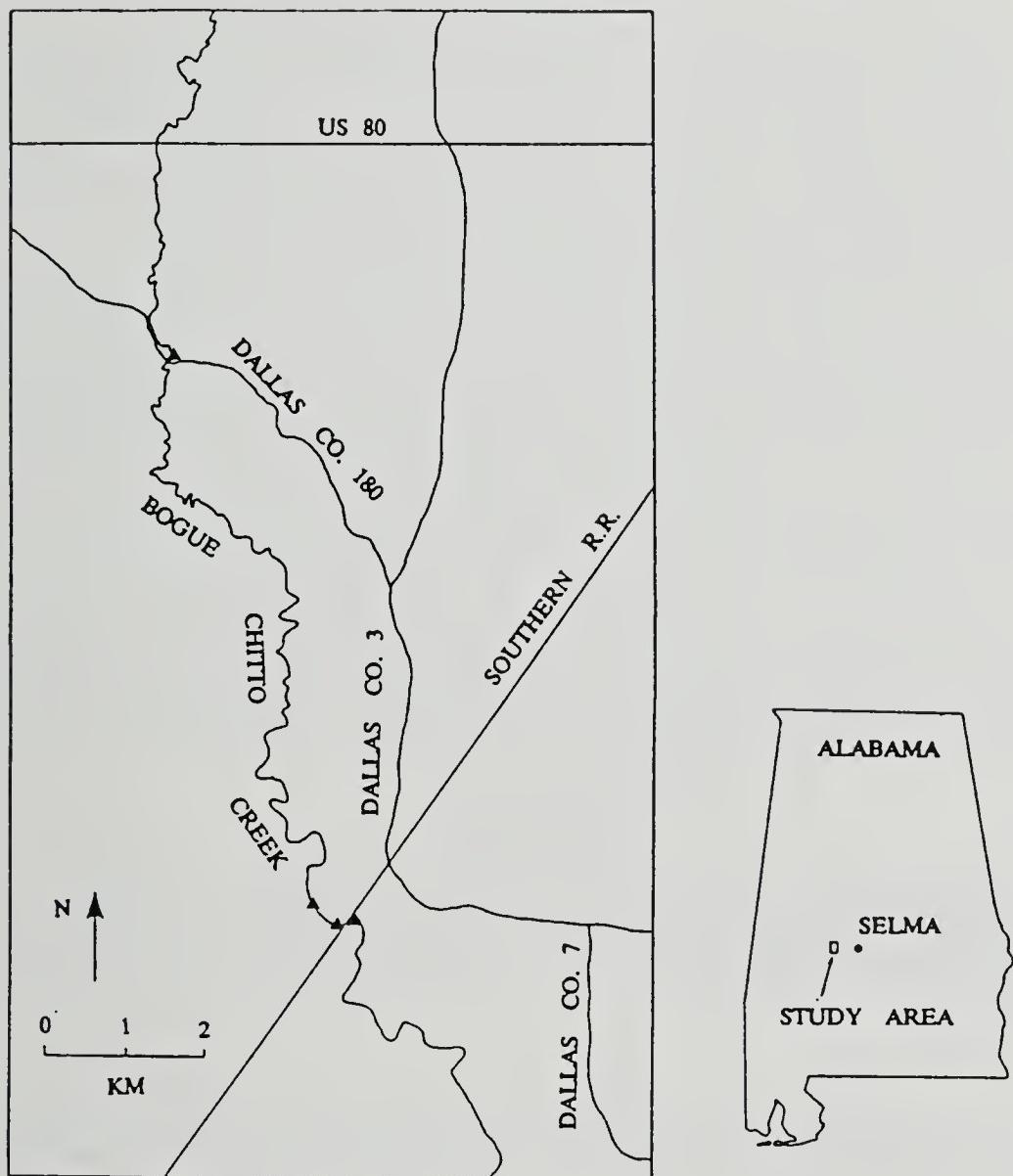


Figure 1. Map showing study area in relation to Selma, Alabama. Detail shows localities (solid triangles) along Bogue Chitto Creek. U. S. Highway 80 is shown near the top of the detail map. Localities near the Southern Railroad tracks were reached by parking along Dallas County Road 3 and walking along the tracks to the creek.

Bogue Chitto Creek is approximately 19 kilometers long with its head waters in Perry County, Alabama, and its mouth in Dallas county, Alabama where it enters the Alabama River. Approximately 6 kilometers from its headwaters, Bogue Chitto Creek becomes incised into the underlying Mooreville and Demopolis Chalks. No fossil material was found upstream from this point. In addition, no fossil material was found down stream for approximately the last 6 kilometers of the stream.

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Collection efforts were concentrated on four productive sites along the creek (Figure one). All fossil material was found on streambed gravel bars or within the stream banks. Material from the banks was collected by screening bulk-sediment samples. These sediments are fluvial and are assumed to represent older deposits of Bogue Chitto Creek. In addition to the Pleistocene mammals; turtles and a snake, Pleistocene freshwater gastropods and macro-plant detritus, as well as reworked Late Cretaceous vertebrate bone and invertebrate steinkerns were found.

Because the majority of specimens from Bogue Chitto Creek were found in streambed gravel bars it is assumed that the fossils had been reworked at least once. In addition, the incomplete nature of the material screen-washed from the stream banks also indicates at least one reworking episode. The reworked nature of the specimens indicates that temporal mixing from several different time periods may have occurred. At present, no taxon whose temporal range ends prior to the Sangamonian has been recovered from Bogue Chitto Creek. This indicates that if temporal mixing has occurred, it is limited to Sangamonian through Recent time.

The fossils are more common within streambed gravel bars than in the stream banks. The concentration of fossils within the streambed probably occurs as the creek meanders across its flood plain (Behrensmeyer, 1982). The sudden appearance of fossils downstream is thought to represent the stream cutting into the first sediments that contain Pleistocene fossils. Upstream from this point the stream reworks more recent sediments.

Systematics

Order Edentata

Holmesina septentrionalis

AUMP 3263

AUMP 3263 is a dermal scute assigned to *H. septentrionalis* based on its overall size and morphology. It compares well with those reported by James (1957).

Dasypus bellus

AUMP 3222, 3173, 3209, 3277, 3214

Thirteen dermal scutes are assigned to *D. bellus*, they resemble the scutes of extant *D. novemcinctus* but generally are larger. Kippel and Parmalee (1984) report overlap in the size of small *D. bellus* and large *D. novemcinctus* scutes. A plot of scute thickness versus width (Figure two) shows that specimens reported here fall well within the range of *D. bellus* (see Martin, 1974; Klippel and Parmalee, 1984).

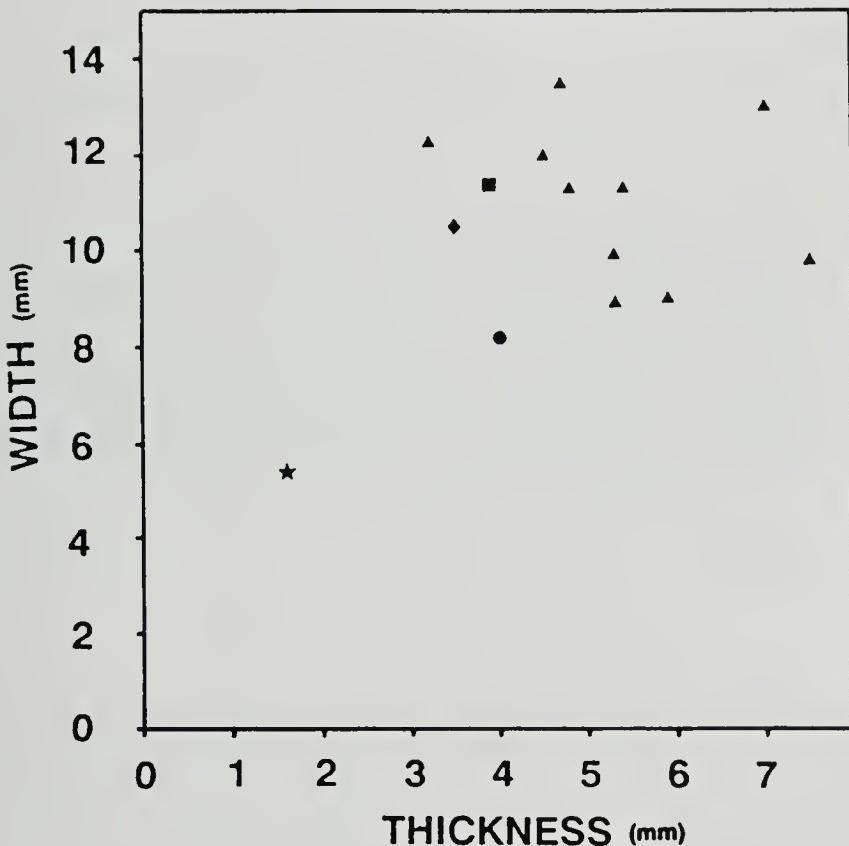


Figure 2. Scute width versus thickness for *Dasypus bellus* dermal scutes. Symbols as follows: triangles = individual scute from AUMP collection; circle = Irvingtonian composite; diamond = Bancan composite; square = Rancholabrean composite; star = *Dasypus novemcinctus* Recent composite. Non-AUMP data taken from Klippe and Parmalee (1984).

Magalonyx jeffersonii

AUMP 3245

AUMP 3245 is a partial tooth assigned to *M. jeffersonii* based on its simple trapezoid shape and its internal structure. The teeth of *M. jeffersonii* are simple box like trapezoids compared to the simple, but more convoluted, teeth of *Glossotherium harlani*. The internal structure consists of an inner cementum, two layers of dentine and one enamel layer. In contrast, *G. harlani* possesses only one dentine layer (Stock, 1925).

Glossotherium harlani

AUMP 3179, 3180, 3203

All materials of *G. harlani* is represented by postcranial elements. They include a mesocuneiform (3180), and phalanx I (3203, 3179).

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Order Carnivora

Vulpes vulpes

AUMP 2955

AUMP 2955 is an edentulous right dentary missing the posterior portion of the ramus. The specimen is referred to *V. vulpes* based on its general shape and measurements (length of tooth row minus canine = 53.0 mm; depth of dentary at M/3=14.8mm), which fall within observed ranges (Anderson, 1968). *Vulpes vulpes* is extant in the study area but AUMP 2955 has the same general degree of preservation as most non-dental fossil material and is not thought to represent recent input to the stream.

Carnivora indeterminate

AUMP 3238

AUMP 3238 is an isolated terminal phalange. This specimen is well preserved and is not thought to represent recent input to the stream. This, however, cannot be definitively shown.

Order Rodentia

Castoroides ohioensis

AUMP 3259

AUMP 3259 is an incisor fragment. The grooved incisors of *C. ohioensis* are diagnostic for the recognition of the species (Martin, 1969; Erickson, 1962). The fragment is small, but shows five grooves one of which is noticeably wider than the others.

Castor canadensis

AUMP 3172, 2971

Castor canadensis is extant in the study area and represented here by a LM/1or2 (3172) and RM/1or2 (2971). These specimens have the same degree of preservation as the other fossil teeth and are not thought to represent recent input to the stream.

Ondatra zibethicus

AUMP 2959, 2969

AUMP 2959 is an isolated M2/, AUMP 2969 is the anterior half of a LM/1. Both specimens were compared to recent *O. zibethicus* dentitions and slight

differences were seen. In the recent material reentrant angles are slightly more narrow and the buccal salient angle and the lingual salient angles are smaller. Both of these features, however, are highly variable and AUMP 2959 falls within this variation. In addition, measurements of AUMP 2959 (L=4.0mm, W=3.1mm, H=11.0mm) fall within measurements reported for *O. zibethicus* (Stephens, 1960).

Order Lagomorpha

cf. *Lepus* sp.

AUMP 2948

Distinguishing between isolated dental material of *Lepus* and *Sylvilagus* is difficult. High variability in the dentitions, even at the generic level, make confident identifications elusive. Comparisons with recent material show *Lepus* to be larger and thus more like AUMP 2948 than to recent *Sylvilagus*. Six other isolated lagomorph teeth were recovered but cannot be confidently identified to the generic level. AUMP 2948 is most similar in size and morphology to *L. americanus* but is also morphologically similar to *L. townsendii* and *L. alleni*.

Order Perissodactyla

Equus sp.

AUMP 2957, 3241, 3253, 3166, 3167, 3181

Numerous teeth, tooth fragments and an isolated terminal phalange are represented. Hay (1923) reported *Equus leidyi* from Bogue Chitto Creek based on a single tooth. We refrain from making any species-level identification (see Kurten and Anderson, 1980, p.283) as the sample size of complete teeth is small.

Tapirus veroensis

AUMP 2942, 2966, 3169, 3170, 3171, 3198, 3215, 3216, 3217, 3244, 3284, 3285, 3286, 3945, 3946

Simpson (1945) recognized two common eastern North American species of tapir, *T. veroensis* and *T. copei*. *Tapirus copei* was erected by Simpson (1945) to

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replace the name *T. haysii*, then used for the larger easter North American species. Simpson (1945) argued that ambiguous use in the published literature of *T. haysii* and questionable locality data of the type specimen justified doing so. This change in nomenclature was observed until Ray and Sanders (1984) re-erected *T. haysii* after re-establishing the locality of the type specimen. Here we followed Ray and Sanders (1984) in the differentiation of *T. veroensis* and *T. haysii*.

Table one gives length and width measurements for all post-canine upper tapir teeth recovered from Bogue Chitto Creek. The measurements are within the observed ranges published for *T. veroensis* (Ray and Sanders, 1984; Lundelius and Slaughter, 1976; Simpson, 1945) and indicate that all teeth belong to *T. veroensis* rather than *T. haysii*.

Table 1

Dental measurements for specimens of upper molars of *Tapirus veroensis*.

AUMP #	Position	PW	AW	L
2966	LM3/	23.2	27.4	24.2
3170	LM1/	24.5	27.4	23.1
3171	LM2/	24.1	29.2	26.1
3198	LP2/	21.4	19.8	18.0
3215	LM1/	23.9	25.6	22.0
3216	RP?/	23.4	----	----
3244	RM3/	21.3	26.9	23.7
3284	RP3/	21.7	22.3	18.7
3957	LP4/	23.5	24.2	20.4

Order Artiodactyla

Odocoileus virginianus

AUMP 3168, 3197, 3292, 3295, 3825

These specimens compare well to Recent specimens of *O. virginianus*. The degree of preservation (lighter in color, softer roots) of one specimen (AUMP 3168) indicates that it may be a more recent addition to the streambed.

Artiodactyla indeterminate

AUMP 3175

AUMP 3175 is a partial lower molar. This specimen is too large to be *Odocoileus* and is probably a camelid. The fragmentary nature of the specimen limits its identification. This specimen is well preserved and is not thought to represent recent input to the stream. This, however, cannot be definitely shown.

Order Proboscidea

Mammut americanum

AUMP 3178, 3199

AUMP 3199 is a first metatarsal and AUMP 3178 is a first terminal phalange. These elements are assigned to *M. americanum* based on their overall size. Measurements are as follows: AUMP 3199, L=98.9mm, W=70.8mm; AUMP 3178, L=52.5mm, W=67.6mm. In addition to these two elements, numerous enamel fragments in the AUMP collection are assigned to *M. americanum*.

Conclusion

Hay (1923) assigned an Aftonian age to the deposits along Bogue Chitto Creek based on the presence of *Elephas imperator*, *Mammut americanum*, and *Equus leidy*. The *Elephas imperator* specimen reported by Hay (1923) is an incomplete lower left molar. We have not examined this specimen by question its identification based on the current practice of not assigning species level identifications to isolated *Mammuthus* molars (Maglio, 1973; Kurten and Anderson, 1980; Roth, 1989). At present there are four recognized North American species of *Mammuthus*: *M. meridionalis*, *M. columbi*, *M. jeffersonii*, and *M. primigenius*. *Elephas imperator* has been synonymized with *Mammuthus columbi* (Kurten and Anderson, 1980). The temporal range of *M. columbi* is middle Irvingtonian through middle Rancholabrean, still consistent with Hay's assignment of an Aftonian age. Alternatively, the specimen may belong to *M. jeffersonii* which is thought to be Wisconsinan in age. We have discovered no new *Mammuthus* material from Bogue Chitto Creek and consider Hay's assignment of his specimen to *E. imperator* as insupportable.

Hay's (1923) assignment of an isolated upper right molar to *Equus leidy* is also thought to be insupportable. Current practice once again avoids species level identifications based on isolated equid molars (Kurten and Anderson, 1980). In addition, *E. leidy* is itself poorly supported as a distinct species (see Hay, 1913) and is probably synonymous with another more common species of *Equus*.

The addition taxa reported here allow the age to be revised to the Rancholabrean. The known temporal distributions for the taxa reported here are shown in Table 2. The presence of *Megalonyx jeffersonii* and *Tapirus veroensis* allow

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the age to be narrowed to the Rancholabrean (temporal ranges taken from Kurten and Anderson, 1980). Table two shows the absence of taxa with last occurrences prior to the Sangamonian, this indicates to us that deposition of these deposits probably occurred after the Illinoian. Deposition of Pleistocene stream deposits along the Gulf Coastal Plain most likely occurred during marine transgressions (Webb and Wildens, 1984). Marine transgressions occurred during glacial to interglacial transitions, with such a transition occurring in the latest Wisconsinan.

Table 2

Temporal distributions for all taxa reported here. Letters at top represent standard North American Land Mammal "Age" and glacial-interglacial terminology. Abbreviations as follows: IRV=Irvingtonian NALMA, RAN=Rancholabrean NALMA, N=Nebraskan, A=Aftonian, K=Kansan, Y=Yarmouthian, I=Illinoian, S=Sangamonian, W=Wisconsinan, R=Recent

TAXA	IRV					RAN		
	N	A	K	Y	I	S	W	R
<u>Holmesina septentrionalis</u>	X	X	X	X	X	X	X	
<u>Dasypus bellus</u>		X	X	X	X	X	X	
<u>Megalonyx jeffersoni</u>					X	X	X	
<u>Glossotherium harlani</u>		X	X	X	X	X	X	
<u>Vulpes vulpes</u>						X	X	X
<u>Castoroides ohioensis</u>		X	X	X	X	X	X	
<u>Castor canidensis</u>	X	X	X	X	X	X	X	X
<u>Ondatra zibethica</u>					X	X	X	X
<u>Lepus</u> sp.	X	X	X	X	X	X	X	X
<u>Equus</u> sp.	X	X	X	X	X	X	X	
<u>Tapirus veroensis</u>						X	X	
<u>Odocoileus virginianus</u>	X	X	X	X	X	X	X	X
<u>Mammut americanum</u>		X	X	X	X	X	X	

Alternatively, the absence of taxa with last occurrences prior to the Sangamonian may be an artifact of preservation, collection or both. In addition, many of the taxa listed in table two have first occurrences prior to the Sangamonian and their presence may be due to reworking of older deposits.

The fauna reported here suggests that several ecological habitats were close to the site of fossil preservation. *Ondatra* and *Castor* are known to inhabit wetlands (Nelson and Semken, 1970; Chapman and Feldhamer, 1982). Likewise, *Castoroides* is inferred to occupy the same habitat. *Tapirus* is known to occur in wooded or grassy habitats as long as water is abundant (Hershkovitz, 1954). The abundance of *Equus*

remains indicates that grass lands, suitable for grazing were present. In addition, many other taxa (*Mammut*) are known or inferred to at least occasionally inhabit grasslands. The presence of *D. bellus* is believed to indicate mild winters ("no more severe than is found in North Central Texas today") with rainfall greater than twenty inches per year (Slaughter, 1961). Just as a more precise age assignment is prevented by the probability of reworking in the past, so to the presence of contemporary ecological habitats may be an artifact of reworking.

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Literature Cited

- Anderson, E. 1968, Fauna of Little Box Elder Cave, Converse County, Wyoming: The Carnivora. Univ. Colo. Stud. Ser. Earth Sci. 6:1-59.
- Behrensmeyer, A. K., 1986, Time resolution in fluvial vertebrate assemblages. Paleobiology, 8:211-227.
- Chapman, J. A., and Feldhamer, G. A., eds., 1982, Wild Mammals of North America: Biology, Management, and Economics. The Johns Hopkins University Press, Baltimore, 1147 p.
- Erickson, B. R., 1962, A description of *Castoroides ohioensis* from Minnesota. Minnesota Academy of Science, Proceedings, 30:7-13.
- Hay, O. P., 1913, Notes on some fossil horses, with descriptions of four new species. Proc. U. S. Nat. Mus. 44:569-594.
- Hay, O. P., 1923, The Pleistocene of North America and its vertebrated animals from the states east of the Mississippi River and from the Canadian provinces east of longitude 95°. Carnegie Inst. Washington Publ. 322:1-499.
- Hershkovitz, P., 1954, Mammals of northern Colombia, preliminary report no. 7: tapirs (Genus *Tapirus*), with a systematic review of the American species. Proceedings of the United States National Museum, 103:469-496.

Additional Pleistocene Mammals

- James, G. T., 1957, An edentate from the Pleistocene of Texas. *J. Paleont.* 31:796-808.
- Klippel, W. E., and Parmalee, P. W., 1984, Armadillos in North American late Pleistocene contexts, pp. 149-160 in Genoways, H. H., and Dawson, M. R., eds, Contributions in Quaternary Vertebrate Paleontology: A Volume in Memorial to John E. Guilday. Special Publications of Carnegie Museum of Natural History, n. 8.
- Kurten, B., and Anderson, E., 1980, Pleistocene Mammals of North America. Columbia University Press, New York, 442 p.
- Lundelius, E. L., Jr., and Slaughter, B. H., 1976, Notes on American Pleistocene tapirs, pp. 226-243 in Churcher, C. S., ed., Essays on Paleontology in Honor of Loris Shano Russell. Royal Ontario Mus., Life Sci. Misc. Publ. Athlon.
- Maglio, V. J., 1973, Origin and evolution of the Elephantidae. *Trans. Amer. Phil. Soc.* NS 63(3):1-149.
- Martin, R. A., 1969, Taxonomy of the giant Pleistocene beaver *Castoroides* from Florida. *J. Paleont.* 43:1033-1041.
- Martin, R. A., 1974, Fossil mammals from the Coleman IIA fauna, Sumpter County, pp. 35-99 in Webb, S. D., ed., Pleistocene Mammals of Florida. University Presses of Florida, Gainesville.
- Nelson, R. S., and Smken, H. A., 1970, Paleoecological and stratigraphic significance of the Muskrat in Pleistocene deposits. *Bull. Geol. Soc. Amer.* 81:3733-38.
- Ray, C. E., and Sanders, A. E., 1984, Pleistocene tapirs in the eastern United States, pp. 283-315 in Genoways, H. H., and Dawson, M. R., eds., Contributions in Quaternary Vertebrate Paleontology: A Volume in Memorial to John E. Guilday. Special Publication of Carnegie Museum of Natural History, n.8.
- Roth, V. L., 1989, Fabricational noise in elephant dentitions. *Paleobiology*. 15(2):165-179.
- Simpson, G. G., 1945, Notes on Pleistocene and Recent tapirs. *Bull. Amer. Mus. Nat. Hist.* 86:37-81.
- Slaughter, B. H., 1961, The significance of *Dasyurus bellus* (Simpson) in Pleistocene local faunas. *The Texas Journal of Science*, 13:311-315.
- Stephens, John J., 1960, Stratigraphy and paleontology of a late Pleistocene basin, Harper County, Oklahoma. *Bull. Geol. Soc. Amer.* 71:1675-1702.

Stock, C., 1925, Cenozoic gravigrade edentates of western North America with special reference to the Pleistocene Megalonychidae and Mylodontidae of Rancho La Brea. Carnegie Institute Washington Publication 331:1-206.

SELF-ASCRIBED TRAITS IN RELATION TO AVOWED HAPPINESS¹

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Abstract

Several situational and dispositional predictors of happiness have been previously reported by investigators. This research explored the relationship between self-attribution of traits and the avowal of happiness. Initially, 84 persons rated the desirability of 21 traits, including *happy*. Then, 216 different subjects completed a questionnaire in which they rated themselves on these same 21 traits using six-point Likert scales. Also, each subject completed the Social Desirability Scale. The results indicated that happier men and women tended to report themselves as being more relaxed, aggressive, cooperative, self-confident, trusting, and sociable; but less timid and introverted. Happier men described themselves as being more practical, religious, conventional, tolerant, and studious; but less cynical and self-centered. Happier women described themselves as being less lazy. These results suggest that happier people tend to describe themselves in more positive terms; however, they do not indicate whether happier people are that way because they possess more desirable traits and fewer undesirable traits, or whether happier people are more self-tolerant. Since self-attributions do relate to happiness, it is possible that psychotherapies which encourage more favorable ones should increase happiness in the recipient.

In his *Nicomachian Ethics*, Aristotle concluded some 2300 years ago that humans seek happiness more than anything else. In subsequent years there have been many theories of happiness and prescriptions for its attainment. There is a natural tendency to look for situational determinants of that desired state; some of the situational variables that have been found to impact on happiness are presented in Table 1.

An emphasis on situational determinants of personality may result in an equation of seeking happiness through obtaining pleasure and avoiding pain. Jeremy Bentham essentially adopted this view in his Utilitarianism political movement (Hergenhahn, 1993). A most primitive form of hedonism may be described as *sensualism*.

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Table 1

Situational Factors Correlated with Happiness

Situation	Direction of More Happiness	Reference
1. Friendship	Having more friends	Larson, 1978
2. Love	Being/having a lover	Braiker & Kelley, 1979
3. Unemployment	Not being unemployed	Warr & Payne, 1982
4. Marriage	Being married	Veroff, Douvan, & Kulka, 1981
5. Leisure	Enjoying more	Campbell, Converse, & Rodgers, 1981
6. Physical attractiveness	Being more attractive	Bersheid & Walster, 1974
7. Personal competence	Being more competent	Headey & Wearing, 1976
8. Pay/salary	Receiving more	Argyle, 1987
9. Promotion opportunities	Having more available	Argyle, 1987
10. Social class	Belonging to a higher social class	Warr & Payne, 1982
11. Health	Being healthier	Okun, Stock, Haring, & Witten, 1984
12. Age	Being youthful	Kuhlen, 1948
13. Parents' happiness	Parents being happier	Wilson, 1960
14. Family adjustment	Having better adjustment	Wilson, 1960
15. Occupational status	Having higher status	Inkeles, 1960

A problem with equating happiness with obtaining pleasure and avoiding pain is that people tend to readjust their assessments of the positive or negative hedonic tone of situations based upon what they have become accustomed. Even more troublesome is the idea from the opponent-process theory of acquired motivation

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which suggests that frequently indulged pleasures tend to become less pleasurable with time (Solomon, 1980). This notion would necessarily cast doubts on the long-term efficacy of strategies for seeking happiness through sensual means alone: in order to keep constant the apparent magnitude of sensual pleasure, some corresponding increase in the objective magnitude of the sensory experience would be necessary.

Some persons, notably Epicurus, have counseled seeking happiness through the avoidance of pain rather than through the active pursuit of pleasure. He advocated living a life of moderation and detachment from worldly affairs (Copleston, 1964). Leading this life of moderation reduces the likelihood of many of the problems of adaptation that would stem from sensualism, including the opponent processes that modify pleasures and pains. However, it is hard to delineate where moderation ends and excess begins. Still, this view might effectively dissuade persons from adopting more extreme styles of pleasure-seeking, such as through alcohol, food, drug, or sexual excesses.

It is also noteworthy that one of the noble truths of Zen Buddhism asserts that unhappiness is caused by craving (Mikulas, 1978). In fact, the Zen Buddhist philosophy regarding happiness prescribes withdrawal from the endless cycle of desire and satisfaction and desire again.

Other approaches to happiness have stressed the importance of dispositional factors (traits). As Table 2 indicates, many of these have been identified. Among the many significant predictors of a person being happy is having higher self-esteem, being extroverted, being optimistic, believing that one has strong control over one's life, and having a self-image that is closer to one's ideal self. Several of these variables are aspects of the self-concept (Wylie, 1979).

Of particular interest is the report by Wilson (1967) that happier people had smaller discrepancies between their ideal selves and their self-images. Happier people should, therefore, evaluate themselves more favorably. Earlier Laxer (1964) presented some evidence supporting this notion. The purpose of this research was to study possible relationships between reported self-perceptions and subjective assessments of personal happiness. We tentatively hypothesized that happier people would report themselves in the more favorable direction on traits.

A possible confounding factor in this research is that persons' self-ratings may be affected by the social desirability motive (Crowne and Marlowe, 1964). Accordingly, this study also looked into the relationship between social desirability and happiness and tried to control this extraneous variable.

Method

Initially 59 women and 25 men rated a list of 21 traits that were selected by the researcher as to their desirability using a five-point scale in Likert format (5: very desirable, 3: neutral; 1: very undesirable).

Table 2

Personality Traits Correlated with Happiness

Trait	Direction of More Happiness	Reference
1. Self-esteem	Higher self-esteem	Campbell, 1981
2. Introversion-Extraversion	Being more extraverted	Costa, McCrae, & Norris, 1981
3. Self-image and ideal self	Having less discrepancy	Wilson, 1967
4. Optimism	Being more optimistic	Matlin & Gawron, 1979
5. Neuroticism	Being less neurotic	Costa & McCrae, 1980
6. Loneliness	Less loneliness	Peplau & Perlman, 1982
7. Locus of control	Internal locus of control	Diener, 1984
8. Religiousness	Being more religious	Wessman, 1956
9. Self-consciousness	Being less self-conscious	Watson, 1930
10. Aspiration level	Having a modest level	Wilson, 1960
11. Evenness of temper	Being more even-tempered	Sailer, 1931
12. Self-descriptions	Having more favorable ones	Laxer, 1964
13. Attitudes toward time	Having more positive attitudes	Wessman & Ricks, 1966
14. Psychological reactance	Having less reactance	Joubert, 1990

A different set of 137 women and 70 men college students from general psychology classes anonymously and voluntarily participated as subjects: most were in the 18- to 25-year-old range, and about 90% were Caucasian. Each person filled out a questionnaire performing self-ratings on the same 21 traits including happiness, using a six-point scale in Likert format for each (0: very much unlike me; 5: very much like me).

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Additionally, each person responded to the 33-item Social Desirability Scale (Crowne & Marlowe, 1964). This scale measures the need for approval, a motive to present oneself in a favorable light to other people. An example of an item from this scale is "I never resent being asked to return a favor." Sixteen additional persons were eliminated due to their failure to rate themselves on all of the self-descriptors or to complete the Social Desirability Scale.

Results

A trait was deemed "desirable" or "undesirable" if its mean desirability rating was significantly greater than or less than 3.00, respectively. Ratings of the desirability to traits indicated that both sexes viewed thirteen of the traits as desirable and three as undesirable. Additionally, men (but not women) rated the trait *aggressive* as desirable and women (but not men) rated the traits *cynical*, *dogmatic*, and *introverted* as undesirable. These traits and their desirability ratings are shown in Table 3.

Comparison of the mean desirability ratings of the traits for the sexes indicated that women rated more so than did men the traits of *happy* and *religious* as more desirable and the trait of *self-centered* as less desirable.

The means and standard deviations of the self-ratings of traits used in this study are reported in Table 4. Men described themselves as being more relaxed, creative, and introverted than did women; but women described themselves as more cooperative, trusting, religious, and studious than did men.

Because sex differences in average ratings on several of these self-descriptors occurred, it was deemed desirable to employ separate-sex Pearson correlational analyses. The results of these separate analyses, as well as the overall correlational analyses of these self-descriptors with avowed happiness, are presented in Table 5. This same table also presents the correlations between these self-descriptions and social desirability for the two sexes.

These results indicate that both men and women who described themselves as being happier also described themselves as being more relaxed, aggressive, cooperative, trusting, self-confident, and sociable; but less timid and introverted. Men (but not women) who were happier also saw themselves as being more practical, religious, conventional, tolerant, and studious but less cynical and self-centered. Happier women also described themselves as being less lazy. Considering the relationship between reported happiness and self-descriptors, the self-described happier people (irrespective of sex) described themselves as being more relaxed, practical, aggressive, cooperative, trusting, religious, self-confident, conventional, tolerant, sociable, and studious but less timid, introverted, lazy, self-centered, and cynical.

Table 3

Desirability Rating of Traits

	Men		Women					
Trait	Mean	SD	Mean	SD	t	df	p	
A. Traits viewed as desirable by both men and women								
Happy	4.56	.77	4.88	.38	-2.58	82	<.02	
Relaxed	4.60	.58	4.36	.78	1.40	82		
Practical	4.16	.69	4.00	.70	0.47	82		
Cooperative	4.48	.59	4.73	.52	-1.93	82		
Trusting	4.48	.65	4.58	.99	-0.45	82		
Self-confident	4.36	.91	4.34	.61	0.12	82		
Creative	4.40	.64	4.24	.82	0.89	82		
Conventional	3.64	.91	3.44	.77	1.03	82		
Religious	3.96	1.02	4.49	.75	-2.87	82	<.01	
Intelligent	4.60	.58	4.53	.70	0.47	82		
Tolerant	3.92	.58	4.20	.76	-1.67	82		
Sociable	4.28	.68	4.37	.64	-0.60	82		
Studious	4.00	.87	4.10	.80	-0.52	82		
B. Traits viewed as undesirable by both men and women								
Self-centered	1.96	1.31	1.34	.71	2.81	82	<.01	
Timid	2.04	.79	2.24	.92	-0.94	82		
Lazy	1.79	.83	1.53	.92	1.23	81		
C. Traits viewed as undesirable by women only								
Cynical	2.88	.88	2.59	1.21	1.07	82		
Introverted	2.96	.91	2.60	.92	1.62	79		
Dogmatic	2.68	.90	2.62	.97	0.26	81		
D. Traits viewed as desirable by men only								
Aggressive	3.60	.96	3.14	1.18	1.74	82		
E. Traits viewed as neither desirable nor undesirable								
Anxious	3.24	1.05	2.92	1.29	1.11	81		

Note: Ratings of the desirability of these traits were measured using five point Likert scales with 5: very desirable, 3: neutral, and 1: very undesirable.

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Table 4
Self-rating of Traits

Trait	Men		Women		t	p
	Mean	SD	Mean	SD		
A. Traits viewed as desirable by both men and women						
Happy	4.03	.93	4.18	.77	-1.34	
Relaxed	3.80	1.08	3.47	1.05	2.20	<.05
Practical	3.68	.83	3.90	.92	-1.71	
Cooperative	4.05	.77	4.31	.65	-2.61	<.01
Trusting	4.05	.92	4.40	.84	-2.86	<.01
Religious	3.33	1.41	3.84	1.08	-2.98	<.01
Self-Confident	3.58	1.07	3.37	1.12	1.35	
Creative	3.56	1.02	3.07	1.27	2.89	<.01
Conventional	3.10	.94	3.21	1.02	-0.79	
Intelligent	3.76	.66	3.74	.65	0.24	
Tolerant	3.62	1.04	3.52	.99	0.72	
Studious	2.98	1.09	3.42	.94	-3.13	<.01
Sociable	3.77	.97	4.00	.85	-1.80	
B. Traits viewed as undesirable by both men and women						
Self-centered	1.95	1.39	1.67	1.30	1.50	
Lazy	2.38	1.38	2.37	1.30	0.08	
Timid	1.80	1.29	2.04	1.48	-1.24	
C. Traits viewed as undesirable by women only						
Cynical	2.27	1.38	2.00	1.16	1.51	
Introverted	2.28	1.48	1.68	1.43	2.93	<.01
Dogmatic	2.17	1.16	2.19	1.33	-0.14	
D. Traits viewed as desirable by men only						
Aggressive	3.13	1.28	2.85	1.36	1.49	
E. Traits viewed as neither desirable nor undesirable						
Anxious	3.54	1.05	3.45	1.19	0.62	
F. Social						
Desirability	14.87	5.20	15.66	5.22	-1.07	

Note: Personality self-ratings were measured on a six-point Likert scale with 5: very much like me and 0: very much unlike me. The Social Desirability Scale contained 33 true-false items.

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Table 5

Correlates of Social Desirability and Self-reported Happiness

	Social Desirability			Happiness		
	Men	Women	All	Men	Women	All
Social desirability				.17	.26 ^c	.23 ^c
A. Traits viewed as desirable by both men and women						
Relaxed	.17	.16	.15 ^c	.37 ^c	.43 ^c	.39 ^c
Practical	.42 ^c	.16	.25 ^c	.39 ^c	.13	.24 ^c
Cooperative	.20	.34 ^c	.29 ^c	.23 ^a	.29 ^c	.27 ^c
Trusting	.33 ^c	.34 ^c	.35 ^c	.40 ^c	.25 ^c	.33 ^c
Self-Confident	.32 ^c	.17 ^a	.21	.52 ^c	.36 ^c	.41 ^c
Creative	-.02	.07	.03	-.11	.10	.01
Conventional	.13	.03	.06	.33 ^c	.08	.18 ^c
Religious	.05	.14	.11	.40 ^c	.10	.26 ^c
Intelligent	-.00	.19	.12	-.09	-.01	-.04
Tolerant	.22	.25 ^c	.23 ^c	.31 ^c	.17	.22 ^c
Sociable	.27 ^b	.20 ^c	.23 ^c	.59 ^c	.47 ^c	.53 ^c
Studious	.22 ^a	.17 ^a	.20 ^c	.36 ^c	.04	.19 ^c
B. Traits viewed as undesirable by both men and women						
Self-centered	-.26 ^a	-.25 ^c	-.26 ^c	-.26 ^b	-.07	-.16 ^c
Timid	-.26 ^a	.07	-.04	-.38 ^c	-.24 ^c	-.28 ^c
Lazy	-.42 ^c	-.20 ^a	-.28 ^c	-.08	-.21 ^b	-.16 ^a
C. Traits viewed as undesirable by women only						
Cynical	-.21	-.13	-.17 ^b	-.30 ^c	-.07	-.18 ^c
Introverted	-.16	-.00	-.07	-.46 ^c	-.24 ^c	-.34 ^c
Dogmatic	-.18	.03	-.04	-.06	-.04	-.00
D. Traits viewed as desirable by men only						
Aggressive	.18	-.08	.00	.35 ^c	.17 ^a	.23 ^c
E. Traits viewed as neither desirable nor undesirable by either sex						
Anxious	-.07	-.20 ^c	-.15 ^a	-.15	-.05	-.09

Note: $df = 77$ for men; $df = 135$ for women; $df = 214$ for all subjects^ap < .05; ^bp < .02; ^cp < .01

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For the men, 13 of 16 traits correlated with happiness in the predicted direction. For women, 8 of the 18 did so. Only one trait (aggressiveness for women) significantly correlated in a direction different from the expected one.

The mean scores on the Social Desirability Scale indicated that men and women did not differ on that measure, $t = -1.07$. Table 5 presents the correlations between Social Desirability Scale scores and self-ratings on the traits. Persons with higher social desirability correlated self-rating of being more trusting, sociable, and studious and also less self-centered and lazy. Additional significant social desirability-trait correlations were observed for one sex but not the other.

Because many of the self-ratings significantly correlated with social desirability, a further analysis was completed using the partial correlational coefficient in which the Social Desirability Scale scores were controlled. The results of this analysis were essentially similar to those found before partialling out for social desirability: the one exception was that the correlation between avowed happiness and cooperativeness was significant for women ($r_{135} = .22$, $p < .01$) but not for men ($r_{17} = .20$).

Discussion

As predicted, happier people tended to employ more favorable self-descriptions, implying that they have better over all self-concepts. It is not presently clear whether these trends are due to happier people being that way because they possess more desirable traits that enhance their self-esteem, or whether they are simply more tolerant in their self-evaluations. They might be less harsh in self-evaluations of their weaknesses and more favorable in self-evaluations of their strengths. Some parallels may be drawn from the literature on depression: depressed people tend to have attributional biases that dispose themselves toward feeling unhappiness (Abramson, Metalsky, & Alloy, 1989). Also, they are more likely to attribute their successes to external causes and their failures to internal causes.

Matlin and Gawron (1977) reported earlier that happier people were more optimistic. Additionally, research on the effects of mood on memories indicates that people with positive moods are more likely to remember successes while people with negative moods are more likely to remember failures (Wright and Mischel, 1982; Seidlitz & Diener, 1993). The optimistic mood of happy people may result in a mood-congruent bias which causes them to evaluate themselves as possessing more positive traits.

Happier people reported themselves as being more sociable and less introverted; results similar to those found by Costa, McCrae, and Norris (1981). Also, these happier persons were more religious, a result similar to that reported by Wessman (1956).

It is not surprising that the more timid were less happy: their less venture someness would lead to fewer reinforcements and greater feelings of self-deprecation which would detract from the general quality of their lives.

Several specific traits correlated with happiness in the expected direction. Happier people were more relaxed, sociable, cooperative, self-confident, and trusting but less introverted and timid. Happier people also reported themselves as more aggressive. Perhaps this is due to their interpreting "aggressive" as equivalent to "forceful" or "assertive" (as in advertisements calling for "aggressive" salesmen). This is noteworthy because earlier research (Joubert, 1990) indicated that people who were higher in psychological reactance tended to be less happy; psychological reactance involves an aggressive or forceful defense of one's personal freedoms.

Somewhat interesting is the fact that happier women did not report being less self-centered or more practical. These relationships merit possible replication to determine what might be behind them.

An additional curiosity is that happier men were more conventional. This could be because these conventional men tend to experience fewer social rebuffs and therefore experience more happiness. We might wonder, therefore, if conventionality serves as a very useful trait rather than one to be deplored, as an occasional view within psychology has sometime suggested. Nevertheless, there was a lack of a significant relationship between conventionality and happiness for women.

The mean social desirability scores observed in this study correspond well with the means from Crowne and Marlowe's norms (1964). Not surprisingly, several of these self-descriptors correlated with social desirability.

A possible limitation of this present study is that it used a single-item measure of happiness; however, single-item happiness measures have been extensively used (e.g., Andrews & Whitey, 1976; Cantril, 1965; Gurin, Veroff, & Feld, 1960; Hartman, 1934), and have some empirical support. Andrews and Whitey (1976) reported that their single-item happiness measure contained 65% of the valid variance of subjective well-being. Also, a single-item measure corresponds with the popular view of happiness as a global condition. It should be noted, however, that the literature of happiness and "subjective well-being" is replete with alternative, multi-item measures (e.g., Campbell, Converse, & Rogers, 1976; Fordyce, 1977). A replication of this research, using one of these multi-item measures, seems indicated.

While several issues are yet unresolved, these results suggest that psychotherapies that seek to increase these traits in a person or to enhance self-evaluations of these types might also increase happiness. While the situational and trait factors in happiness should not be discounted, improving self-attributions or self-evaluations might also improve happiness. Some of the suggestions of cognitive or

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attributional theorists (e.g., Beck, 1976) could be directed toward the enhancement of happiness in non-depressed persons as well as easing the burden of unhappiness in those that are depressed.

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References

- Abramson, L. T., Metalsky, G. I., & Alloy, G. B. (1989). Hopelessness depression: A theory-based subtype of depression. *Psychological Review*, 96, 358-372.
- Andrews, F. M., & Whitey, S. B. (1976). *Social indicators of well-being: America's perception of life quality*. New York: Plenum Press.
- Argyle, M. (1987). *The psychology of happiness*. London: Methuen.
- Beck, A. T. (1986). *Cognitive therapy and the emotional disorders*. New York: International Universities Press.
- Bersheid, E., & Walster, E. (1974). Physical attractiveness. *Advances in Experimental Social Psychology*, 7, 158-216.
- Braiker, H. B., & Kelley, H. H. (1979). Conflict in the development of close relationships. In R. L. Burgess and T. L. Huston (Eds). *Social exchange in developing relationships*. New York: Academic Press.
- Campbell, A. (1981). *The state of well-being in America*. New York: McGraw-Hill.
- Campbell, A., Converse, P. E. & Rodgers, W. L. (1976). *The quality of American life*. New York: Sage.
- Cantril, H. (1965). *The pattern of human concerns*. New Brunswick, NJ: Rutgers University Press.
- Copleston, F. (1964). *The history of philosophy* (Vol. I). Garden City, NY: Image Books.
- Costa, P. T., & McCrae, R. R. (1980). Somatic complaints in males as a function of age and neuroticism: A longitudinal analysis. *Journal of Behavioral Medicine*, 3, 245-257.

- Costa, P. T., McCrae, R. R., & Norris, A. H. (1981). Personal adjustment to aging: Longitudinal prediction from neuroticism and extraversion. *Journal of Gerontology*, 36, 78-85.
- Crowne, D. P., & Marlowe, D. (1964). *The approval motive: Studies in evaluative dependency*. New York: Wiley.
- Diener, E. (1984). Subjective well-being. *Psychological Bulletin*, 95, 542-575.
- Fordyce, M. W. (1977) *The Happiness Measures: A sixty-second index of emotional well-being and mental health*. Unpublished manuscript, Edison Community College, Fort Myers, FL.
- Gurin, G., Veroff, J., & Feld, S. (1960). *Americans view their mental health*. New York: Basic Books.
- Headey, B., & Wearing, A. (1976). *Chains of well-being, chains of ill-being*. International Sociological Association conference, New Delhi.
- Hergenhahn, B. R. (1993) *An introduction to the history of psychology* (2nd ed.). Belmont, CA: Wadsworth.
- Inkeles, A. (1960). Industrial man: The relation of status to experience, perception, and value. *American Journal of Sociology*, 66, 1147-1151.
- Joubert, C. E. (1990). Relationship among self-esteem, psychological reactance, and other variables. *Psychological Reports*, 66, 1147-1151.
- Kuhlen, R. G. (1948). Age trends in adjustment during the adult years as reflected in happiness ratings. *American Psychologist*, 3, 307. (Abstract)
- Larson, R. (1978). Thirty years of research on the subjective well-being of older Americans. *Journal of Gerontology*, 33, 109-125.
- Laxer, R. M. (1964). Relation of real self-rating to mood and blame, and their interaction in depression. *Journal of Counseling Psychology*, 28, 538-546.
- Matlin, N. W., & Gawron, V. J. (1979). Individual differences in Pollyanaism. *Journal of Personality Assessment*, 43, 411-412.
- Mikulas, W. L. (1978). Four noble truths of Zen Buddhism related to behavior therapy. *The Psychological Record*, 28, 59-67.

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- Okun, M. A., Stock, W. A., Haring, M. J., & Witten, R. A. (1984). Health and subjective well-being: a meta-analysis. *International Journal of Aging and Human Development*, 19, 111-132.
- Peplau, L. A., & Perlman, D. (1982). *Loneliness*. New York: Wiley.
- Sailer, R. C. (1931). Happiness self-estimates of young men. *Teachers College Contribution to Education*, No. 467.
- Seidlitz, L., & Diener, E. (1993). Memory for positive versus negative life events: Theories for the differences between happy and unhappy persons. *Journal of Personality and Social Psychology*, 64, 654-664.
- Solomon, R. (1980). The opponent-process theory of acquired motivation: The costs of pleasure and the benefits of pain. *American Psychologist*, 35, 691-712.
- Veroff, J., Douvan, E., & Kulka, R. A. (1981). *The inner American*. New York: Basic Books.
- Warr, P., & Payne, R. (1982). Experience of strain and pleasure among British adults. *Social Science and Medicine*, 16, 1691-1697.
- Watson, G. B. (1930). Happiness among adult students of education. *Journal of Educational Psychology*, 21, 79-109.
- Wessman, A. E. (1956). *A psychological inquiry into satisfaction and happiness*. Unpublished doctoral dissertation, Northwestern University.
- Wilson, W. R. (1960). *An attempt to determine some correlates and dimensions of hedonic tone*. Unpublished doctoral dissertation, Northwestern University.
- Wilson, W. R. (1967). Correlates of avowed happiness. *Psychological Bulletin*, 67, 294-306.
- Wright, J., & Mischel, W. (1982). Influence of affect on cognitive social learning variables. *Journal of Personality and Social Psychology*, 43, 901-914.
- Wylie, R. G. (1979). *The self-concept: Theory and research on selected topics* (Vol. 2). Lincoln: University of Nebraska Press.

ERGONOMICS APPLIED TO FOREST OPERATIONS: A COOPERATIVE RESEARCH PROGRAM¹

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Abstract

Ergonomics research related to forest harvesting in the southeastern United States and sponsored by the USDA Forest Service's Southern Forest Experiment Station during the 1980 to 1993 time frame is described. A total of 13 studies relating to physiological job demands, heat stress, vibration exposure, and equipment design are reviewed. Anticipated future research activities are indicated.

INTRODUCTION

The forest products industry is one of the largest employers in the southern United States. Forest harvesting activities, the first step in the overall forest products production system, employ numerous individuals on manual, semi-mechanized, and fully mechanized tasks. These tasks are physically stressful and unfortunately associated with relatively high accident/injury frequency and severity rates. Harvesting in the region is accomplished primarily by numerous small scale independent contractors. In addition, several large forest products companies operate a relatively few "company" harvesting crews. Although still requiring the performance of strenuous manual task elements, harvesting is rapidly evolving into a highly mechanized activity utilizing expensive equipment. It is critical that harvesting be accomplished in a cost effective, highly productive manner so as to minimize this aspect of overall wood products production system costs. It is equally important that harvesting be accomplished without imposing undue physical stress and bodily injury and health risks on the workforce.

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In the fall of 1979 the Auburn University Department of Industrial Engineering in cooperation with the university's Engineering Experiment Station and the USDA Forest Service Southern Forest Experiment Station initiated a research program with the overall purpose of enhancing southern forest harvesting productivity through ergonomics research. Ergonomics is the discipline that seeks to assure compatibility between the capabilities and limitations of people and the demands imposed by their work tasks and work environments. Ergonomics is currently commonly identified in the press as being primarily concerned with the prevention of cumulative trauma disorders of the upper extremity and/or the design of personal computer workstations. This characterization is much too limiting, however, as ergonomics is concerned with a broad scope of workplace design - worker interface issues including physiological stress prevention, environmental stress prevention, worker/workplace accommodation, equipment design, and human error minimization. Thus all aspects of forest harvesting, or any other human work activity, could potentially be benefited by ergonomic evaluation, problem identification, and problem resolution.

The first cooperative study undertaken (Smith and Sirois; 1980, 1982) evaluated the available literature relating to forest harvesting ergonomics in terms of its implications to U.S. southern harvesting activities. The literature reviewed was divided into five general topic areas: work physiology, heat stress, vibration and noise stress, equipment design including maintenance, and safety. It was concluded that although considerable ergonomics research had been accomplished outside of the United States its application to the conditions and procedures used in the southern U.S. was limited. It was further concluded that research needed to be performed specifically directed toward southern U.S. harvesting including: 1) assessment of the physical demands of harvesting work, 2) development of an activity guide for work under various thermal environment conditions, and 3) ergonomic evaluation of commonly used harvesting equipment. During the last ten years research has been performed relative to each of the identified topics. The research program has included an evaluation of the physiological demands of six common southern forest harvesting tasks, an evaluation of the effects of summer time heat stress on the productivity of both manual and mechanized harvesting tasks, the development of a heat stress prevention activity guide for use by harvesting managers, an evaluation of the noise and vibration stress experienced by the users of a newly designed two cylinder chainsaw, an evaluation of the whole body vibration exposure of skidder operators, development of a protocol for the ergonomic evaluation of forest machines and its application to mobile chippers, an evaluation of the adequacy of workplace design and seating in grapple skidders, documentation of the work postures assumed by skidder operators and the anthropometric characteristics of the souther harvesting workforce, and evaluation of factors affecting the selection and use of chainsaw operator leg protection devices. A study currently in progress does not involve harvesting operations but nevertheless relates to woods workers; it is developing and

evaluating a new wildland firefighter protective garment. This paper briefly reviews these past and current studies and provides recommendations for additional needed research.

EVALUATION OF PHYSIOLOGICAL DEMANDS

To provide basic data relative to the physical demands of southern harvesting tasks, a study (Smith, Wilson, and Sirois; 1982, 1983) was undertaken to document the physiological stress, as measured by working heart rate levels, imposed upon typical employees by their work activities and work environments. Particular attention was given to the stress imposed by summer thermal environment conditions. Data were collected during the summer of 1981 from four different harvesting crew/harvesting site combinations in east-central Alabama on persons performing the common tasks of chainsaw felling, cable skidding, bucking and trimming prior to loading (job referred to as "landing saw man"), and knuckle-boom loader operating. Data were also obtained at one site on feller-buncher and grapple skidding activities. The heart rate data were obtained without any significant artificial restrictions being placed on the harvesting crew members being observed (Smith and Wilson, 1983), and represented a total of 17 harvesting crew members and a total of 53 hours of actual harvesting activity. Environmental conditions were assessed by measurement of the wet-bulb globe-temperature (WBGT) and ranged from a WBGT of 20°C (68°F) to 34.4°C (94°F).

The data indicated that southeastern forest harvesting tasks performed in summertime environmental conditions place physiological demands on the worker that often equal or exceed the maximum levels typically considered acceptable in occupational activities. Based on the data, the tasks considered may be ranked in decreasing order of physiological demands as follows: (1) landing saw man (heavy work), (2) chainsaw felling (moderate to heavy work), (3) cable skidding (moderate work), (4) grapple skidding (light work), (5) feller-buncher operation (light work), and (6) knuckle-boom loader operation (light work). The environmental conditions were dichotomized into hotter (WBGT > 26.1°C (79°F)) and more moderate conditions (WBGT < or = 26.1°C). On average, work under the hotter environmental conditions resulted in a heart rate increase of approximately 5 BPM when compared with the lower temperature conditions. Furthermore, the number of very stressful cardiac instances (heart rate response greater than 120 BPM) was substantially greater under the higher WBGT level.

In addition to the basic demands data generated, the study results included an important observation which led to later studies of heat stress. The amount of increase in the average work heart rate when work was performed under hot conditions as compared with more moderate conditions was not as great as might reasonably be expected. This suggests that the harvesting employee may perform his work so as not to experience what to him is unacceptable physiological stress by

reducing the amount of muscular work performed. The manner in which the crew member reduces his muscular work per unit time may not be obvious to the casual observer; indeed, it may not even be conscious on the part of the crew member. For instance, it was observed that when temperatures were hotter more "hidden rest period" events, such as hung-up saws, occurred. These events lowered the physiological stress being experienced but also resulted in reduced productivity. As a result of this observation, later research was directed toward determining the relationship between heat stress and worker productivity on southeastern forest harvesting tasks.

HEAT STRESS ASSESSMENT

Three studies have been sponsored by the Southern Forest Experiment Station directly related to heat stress effects on forest harvesting activities. The first (Smith, Seay, and Sirois, 1985) examined productivity on a variety of harvesting tasks and was a direct outgrowth of the physiological demands study. The second (Rummer and Smith, 1990) examined the productivity implications of air-conditioned harvesting machines. The third (Smith and Rummer, 1988) proposed a guide for use by harvesting managers to assist in the prevention of heat stress events.

The objective of the first study was to evaluate the relationship between worker productivity and the level of environmental heat load present during the work activity for commonly performed southern forest harvesting tasks. The tasks evaluated were chainsaw felling, cable skidding, bucking at the landing, feller buncher operation, and bucking bunched thinnings. Historical production data covering a period of 806 crew/days were evaluated for three logging crews from one company in south Alabama. Direct observation data were also obtained from these crews and a thinning crew during the months of July, August, and December. Two feller buncher operators employed by a second company were also observed for one week in August. The direct observation data were obtained by the work sampling technique and totaled 20,661 observations.

Environmental conditions were assessed by the Oxford Index (0.85 wet bulb temp. + 0.15 dry bulb temp.) for the historical data and the WBGT for the direct observation data. The measure of productivity utilized in the historical data evaluation was pounds harvested per man-hour worked. The production behavior variables evaluated by the direct observation study were percentage productive activities, percentage (operator controlled) unproductive activities, worker effort level, worker efficiency, percentage unsafe behavior, and percentage non-use of personnel protection equipment.

The results indicate that logging crew productivity as a whole and the productivity of chainsaw fellers and cable skidder operators in particular experience productivity decreases of 5 to 15% in environmental conditions characterized by the

Oxford Index exceeding 25°C (77°F) or the WBGT exceeding 26.1°C (79°F). Neither type of bucking performance was significantly degraded by the hotter environmental conditions perhaps due to these individuals being underutilized in the harvesting crews observed. The feller-buncher operators experienced a 2 to 3% decrease in percentage productive activities under the hotter conditions. Both of the companies cooperating in this study have active occupational safety programs which strongly encourage appropriate work behavior. None of the observed crew members had unsafe behavior rates greater than two percent. Although there was a tendency for about one-half of the men to engage in more unsafe behavior under higher temperature levels, they did not radically modify their behavior. It must be noted, however, that those individuals exposed to the most direct solar load, the buckers at the landing, tended to neglect their personal protective equipment under the hotter conditions. It was suggested that harvesting management should be alert to this possibility and apply appropriate supervisory controls.

The data did not provide support for a previously published (Axelson, 1974) mathematical model purporting to describe the relationship between reduction in productivity and the temperature of the work area. It appears likely that too many variables in addition to the thermal environment affect harvesting productivity to permit its modeling as a continuous function of an environmental parameter. It thus seems best to evaluate productivity with respect to an environmental "threshold" such as the 25 C Oxford Index value utilized in this study. When thermal conditions exceed the "threshold" level, harvesting managers should expect negative productivity effects to occur.

The second study related to heat stress and productivity, Rummer and Smith (1990), examined the utilization of feller-bunchers to determine if air conditioning affected the way the equipment was used. While it intuitively appears that air-conditioned forest harvesting machines would minimize heat related health and productivity problems, air conditioning is not commonly utilized in the southeastern U.S. There has been a general perception that air conditioning is a high maintenance luxury option rather than a cost/effective part of a harvesting system. It was hypothesized that higher cab temperatures in non air-conditioned machines would reduce productivity by affecting the utilization of the machine rather than the production rate itself. Since the physical demands of machine operation constitute "light work" the metabolic component of the overall work heat load is low. The operator of a non air-conditioned machine, wishing to reduce his exposure level, would have to remove himself from the work task, thus reducing the utilization of the machine.

Time study data and temperature measurements were collected on five air-conditioned and five non air-conditioned feller-bunchers. Although estimated cab WBGT levels in the non air-conditioned machines exceeded levels recommended by various occupational health agencies, the data indicated that length of workday and

crew differences were the only factors that significantly affected machine utilization. Other benefits of utilizing air-conditioned machines were noted however. Increased workplace comfort may make it easier to recruit and retain skilled operators, and exclusion of dust, insects, and noise improve the overall quality of the employee's work environment. These intangible benefits may be sufficient to justify the expense of air conditioning.

The third heat related study, Smith and Rummer (1988), had been recommended as being needed by Smith and Sirois in their 1982 ergonomics research needs report. This study drew from data collected in the previous work physiology and heat stress studies and developed a work practices guide entitled: "Guide to the Prevention of Heat Stress in Forest Harvesting Tasks" intended for use by harvesting managers. The Guide permits assessment of the risk of heat stress occurrence utilizing either measured WBGT values or media reported levels of the Heat Index and dry bulb temperature by consulting conveniently designed tables. Manual, semi-mechanized, and mechanized harvesting tasks are covered by the Guide. The Guide includes discussion of suggested work practices that may be followed so as to reduce the risk of heat stress, discussion of certain "special situations" in which the risk may be higher than usually indicated by the meteorological conditions, discussion of heat illnesses and actions that should be taken if symptoms are observed, and a discussion of the effects of hot working conditions on safe work behavior. A compressed version of the Guide was published by the American Pulpwood Association and distributed to APA members (Smith and Rummer, 1993). The usability of the Guide has not been tested in the field by actual harvesting managers to date.

VIBRATION EXPOSURE ASSESSMENT

Occupational vibration exposure is typically considered in two categories: segmental and whole-body. The greatest health concern in the area of segmental vibration is the occurrence of "hand-arm vibration syndrome" (HAVS) among users of powered hand tools including chainsaws. HAVS is a composite of vascular and neurological disorders that are manifested by pain, numbness, tingling, and eventual necrosis of the fingers. Whole-body vibration is associated with less-specific problems such as discomfort, reduced work proficiency, and a variety of generic physical symptoms including back pain and nausea. Whole-body vibration is typically experienced by forest workers operating off-road vehicles and other machinery. Four studies examined vibration exposures in forest work including: chainsaw vibration, whole-body vibration on rubber-tired skidders, and whole-body vibration in logging trucks.

Rummer, Smith, and Stokes (1985) compared the vibration and noise exposures associated with the use of two models of single-cylinder chainsaws and a two-cylinder chainsaw. Both static bench and dynamic bucking tests were performed. The results indicated the new two-cylinder design had the lowest vibration level. The

latency period before there was a 50% chance of developing HAVS from using the saws four hours per day was estimated to be more than 26 years for the two-cylinder design and less than 12 years for the one-cylinder saws. Noise levels for all of the saws exceeded recommended limits. Under constant speed conditions, the two-cylinder saw had one of the quieter levels of noise; under operator selected speed conditions the noise levels were equivalent. The operators appeared to actually use the noise level produced to establish the speed at which they ran the saws. If this phenomenon is generalizable, it has significant training implications.

Most of the reported studies of whole-body vibration in forest equipment operation have concentrated on measuring vibration exposure levels and comparing them to various exposure guidelines. Many of these studies have been conducted in Scandinavian countries and Canada where harvesting operations may differ from those in the southeastern United States. Rummer's (1988) study surveyed workers' attitudes toward whole-body vibration on forest machines and developed and validated a computer ride simulation model that could be used to improve the design of forest machines with respect to vehicle ride. The operator survey documented demographic data about forest machine operators as well as subjective assessments of work environment factors. On average, the respondents were in their late 30's with approximately 12 years experience as woods workers. It was found the typical workday includes substantial (1.5 hours) travel time to the harvesting site; thus vibration exposure in the crew truck is likely a significant component of the total daily vibration exposure. The survey responses indicated that whole-body vibration is one of the most discomforting aspects of the forest equipment workplace; the top three workplace related job dis-satisfaction factors were reported to be (1) climate, (2) vibration, and (3) exposure to exhaust fumes. The survey did not reveal evidence of physical injury resulting from long-term whole-body vibration exposure. Thomas and Smith (1991) measured whole-body vibration on current rubber-tired skidder models and found that little improvement had been made in equipment design.

The computer ride model developed by Rummer was validated by comparison with vibration levels measured on an actual machine traversing a test track. Results of the test track runs were analyzed to evaluate the effects of travel speed, tire size and inflation pressure, a "bump" in the track, and vehicle operator on the level of whole-body vibration. Travel speed was the most significant factor. An example of the application of computer ride simulation to forest equipment design was developed and the design process was reviewed. It was concluded that use of computer ride simulation fits in well with the iterative nature of the equipment design process.

Whole-body vibration was also investigated in conjunction with USDA Forest Service tests of central tire inflation (CTI) systems for logging trucks. CTI systems permit the driver to reduce tire pressure during low-speed off-highway operation. Reducing tire pressure increases traction and increases road surface life. As part of the evaluation of this technology, whole-body vibration was measured to determine

whether ride was improved at lower tire pressures. Logging site tests (Rummer et al, 1990) indicated that vibration exposure on the seat was minimized at an intermediate tire pressure setting. However, lower tire pressures were also associated with higher travel speeds, suggesting that the operators drove the trucks at speeds that produced a constant level of discomfort. It was also apparent from the data that there are complex interactions between truck, tire, and seat suspension affecting driver vibration exposure.

HARVESTING EQUIPMENT DESIGN

North American forest equipment has historically been designed for functional capability, reliability, and minimal unit cost with only modest consideration given to the capabilities and limitations of workers that must use the equipment. Ergonomics research in a variety of settings has demonstrated that when operators are required to use inappropriately designed information displays and machine controls, maintain strained body postures while attempting to work in poorly arranged equipment cabs, or experience too much heat, noise, dust, and vibration, the overall performance of the entire production system is degraded. As part of the cooperative ergonomic research program, three studies have been conducted and one is in progress to examine various aspects of forest equipment design from an ergonomics perspective. Smith, Helm, and Rummer (1988) and Bellingar (1993) investigated user factors in the design of personal protective equipment; Smith, Adsit, and Rummer (1990) developed a checklist protocol for the ergonomic evaluation of mobile forest machines; and Thomas and Smith (1991) evaluated workplace design and seating in grapple skidders.

A large percentage of logging accidents involve the use of chainsaws. Chainsaw user leg protection is available in several varieties and could be used to prevent or mitigate many chainsaw user injuries. Unfortunately, leg protection has not been widely used by loggers in the southern United States. The Smith, Helm, and Rummer (1988) study sought to contribute to increased leg protection use by evaluating several factors influencing its selection, acceptability, and use. Factors studied were: protective ability, appearance, cost, thermal comfort, mobility, durability, and style.

Leggings, protective pants, work pants with safety insert pads, and chaps along with regular work pants as a control were evaluated in both laboratory and job site studies by five subjects at each test location. A paired comparison test and a ranking test were used to obtain subjective opinions about the leg protection. In the laboratory a forest harvesting task simulation obstacle course was negotiated by the subjects wearing each of the leg protection types at two different temperature conditions: 23°C and 35°C (73.4°F and 95°F). Motion restrictions imposed by the leg protection and leg skin temperature responses were measured during each trial and subjective opinions were obtained by the use of a questionnaire following each trial.

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The job site subjects were encouraged to wear the protection equipment for a week and reported their subjective opinions by responding to a questionnaire. The results suggest that protective ability and thermal comfort are the two factors considered most important in leg protection selection followed closely by mobility. Interestingly, although subjects rated appearance of the equipment as least important of the factors evaluated, all of their informal comments focused on the leg protection's appearance thus suggesting it is an important factor. The effect of the leg protection on worker mobility was not consistent suggesting that different types of leg protection affect mobility in different ways for different people. Based on this study it would appear that anyone promoting the use of chainsaw user leg protection devices should provide a choice of fabric colors, should demonstrate that it is protective, and attest that it is neither too hot nor too restrictive of mobility to be uncomfortable and inconvenient to wear.

In cooperation with Dow Chemical Company, an Auburn University textile researcher developed a new carbon fiber with highly flame resistant insulating properties (McCullough and Hall, 1990). The application of this fiber in the design of clothing worn by forest fire fighting personnel is currently being accomplished by Ms. Teresa Bellingar, an Auburn industrial engineering graduate student (1993). The goal of Bellingar's research is to develop, fabricate, and test in laboratory simulations and actual field use a prototype wildland firefighter clothing ensemble that will increase the safety, mobility, and comfort of wildland firefighters. Cooperating in this project are four Auburn University academic departments: Industrial Engineering, Consumer Affairs, Textile Engineering, Health and Human Performance; two USDA Forest Service laboratories: Auburn and Missoula, MT; and Terry Manufacturing, Inc., an Alabama based apparel company.

The 1990 study by Smith, Adsit, and Rummer sought to compile an evaluation protocol to facilitate the ergonomic analysis of forest machines based on information available from current ergonomic design references, literature reports of related equipment evaluation studies, and government and industry design standards. Once developed, the protocol was applied in a study of mobile chippers.

The evaluation protocol was developed in the form of a checklist. Specific areas of ergonomic concern treated were cab access, cab interior dimensions, operator seat dimensions, control location, control actuating forces, instrumentation, visibility, cab climate, air quality, noise, vibration, and maintenance. In addition to the checklist itself, a questionnaire was developed to obtain subjective information from the operator.

Six mobile chippers were evaluated in the case study and the results indicated there are several areas of ergonomics deficiencies associated with the models evaluated. Most notable were cab access system dimensions and operator seat characteristics. In some models the visibility from the cab, the cab thermal climate,

and the cab noise level were also found to be inadequate. The responses to the subjective questionnaire reinforced these findings.

The goal of the Thomas and Smith (1991) study of the grapple skidder workplace was to reduce operator back injuries by incorporating ergonomic design features in both existing and future grapple skidders. The study included evaluation of existing skidder designs by cab layout analysis, documentation of operator work postures, and measurement of whole body vibration levels. The study included anthropometric assessment of grapple skidder operators. Recommendations for retrofitting existing machines and improving future designs were developed.

Three current skidder models were evaluated: John Deere model 648E, Timberjack model 450B, and Caterpillar model 518. Data were collected at twelve harvesting sites in Alabama and Georgia. Results indicated that grapple skidder operators spend from 27% to 54% of their time in twisted postures that are associated with higher rates of back injury. The variability in "twisted" work posture frequency was a function of both skidder design and operator preference. Placement of grapple controls within proper arm reach envelopes appeared to have potential for significantly reducing operator twisting. Twisted postures also appeared to exacerbate existing interface problems between operators and their control systems. Opportunities for significant design improvement, from an ergonomic standpoint, exist with respect to seating design (especially adjustability), control placement, control actuation force requirements, cab access design, and general cab design.

The results of the anthropometric assessment indicated that southern (USA) skidder operators are generally taller with regard to stature, sitting height, seated eye height, and seated shoulder height than the SAE J898 (SAE, 1993) and ILO (Jurgens, et al, 1990) design reference values. Study operators were also heavier than the reference values in those design standards.

FUTURE RESEARCH

The ergonomics research activities reviewed have focused primarily on harvesting systems with a significant manual labor component manned by employees utilizing very little if any personal protective equipment. Forest harvesting in the southern U.S. will become more and more mechanized as new equipment is introduced to perform traditional activities and demand increases for activities (large scale thinning) and products (chips for fuel) which can only be accomplished with mechanized harvesting systems. Additionally, new safety regulations will mandate the use of appropriate personal protection equipment ensembles. Accordingly, the next phase of the USDA Forest Service/Auburn University ergonomics research program will likely focus upon mechanized harvesting systems and enhancing the design and use of personal protective equipment. Possible studies include an expansion of the previous heat stress and vibration exposure studies to further document the exposure

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of mechanized equipment operators to heat, vibration, noise, and dust hazards and to develop methods to minimize the negative effects of this exposure on operator safety, health, and productivity. The previous anthropometric study should be expanded so as to enhance the development of a southern woods worker anthropometric data base for use by equipment designers. Similarly there should be additional ergonomic evaluation of existing machines so as to suggest improvements in work place design and design for maintainability. Research relative to personal protection equipment design and utilization should lead to ensembles which provide appropriate protection and are acceptable to the workforce. Because they are being increasingly utilized in the woods, the efficacy of currently popular (but unproven) "workstress reduction" devices such as back support belts and wrist/forearm supports must also be examined.

CONCLUSIONS

Ergonomics is a discipline that encompasses the entire range of human-workplace/equipment interaction. By properly incorporating ergonomic principles in the design of systems and equipment, the efficiency of the overall system can be improved. The studies conducted under this cooperative ergonomic research program have touched on ergonomic issues ranging from physical workload and manual materials handling to control location and subjective comfort. The results of these studies have provided new insights into ways to improve forest operations. This model of a broad, coordinated ergonomic research program could be applied to many industrial classifications.

LITERATURE CITED

- Axelson, O., 1974. Heat stress in forest work. Food and Agricultural Organization of the United Nations, Rome. 31 pp.
- Bellinger, T., 1993. Development of prototype wildland firefighter protective clothing. Doctoral Dissertation Proposal, Department of Industrial Engineering, Auburn University, Alabama. 37 pp.
- Jurgens, H. W., Aune, I. A. and U. Pieper, 1990. International data on anthropometry. Occupational Safety and Health Series No. 65. International Labour Office, Geneva. 113 pp.
- McCullough, F. P. and D. M. Hall, 1990. Method of improving the flame retarding and fire blocking characteristics of a fiber tow or yarn. U.S. Patent # 4,950,540.

- Rummer, R. B., 1988. Whole-body vibration exposure of forest equipment operators in the southeastern United States. Doctoral Dissertation, Department of Industrial Engineering, Auburn University, Alabama. 227 pp.
- Rummer, R. B., Ashmore, C., Sirois, D. L. and C. L. Rawlins, 1990. Central tire inflation: demonstration tests in the south. Gen. Tech. Rpt. SO-78, USDA Forest Service, Southern Forest Experiment Station: New Orleans, 11 pp.
- Rummer, R. B. and L. A. Smith, 1990. Utilization of air-conditioned feller/bunchers. International Journal of Industrial Ergonomics. 5,: pp. 293-302.
- Rummer, R. B., Smith, L. A. and B. J. Stokes, (1985). Two-cylinder chain saw vibration and noise test. Technical Release 85-R-13, American Pulpwood Association, Inc. 2 pp.
- Smith, L. A., 1980. Final Report No. 19-353, USDA Forest Service, New Orleans, LA.
Vol. 1: Assessment of the ergonomics literature to identify productivity improvement applications and research needs pertinent to southern forest harvesting. 49 pp.
Vol. 2: an annotated bibliography of selected forest harvesting ergonomics literature. 155 pp.
- Smith, L. A., Adsit, D. A., and R. B. Rummer, 1990. An ergonomic evaluation of forest machines: development of an evaluation protocol and case study of mobile chippers. Final Report No. 19-88-074. USDA Forest Service, New Orleans, LA. 76 pp.
- Smith, L. A., Helm, S. M., and R. B. Rummer, 1988. Evaluation of factors affecting the selection and use of chainsaw leg protection. Final Report No. 19-86-048. USDA Forest Service, New Orleans, LA. 117pp.
- Smith, L. A., and B. Rummer, 1993. Heat Stress: A summertime risk for woodworkers. Technical Release 93-R-61, American Pulpwood Association, Inc. 2 pp.
- Smith, L. A., and R. B. Rummer, 1988. Development of a heat stress prevention activity guide for use by southern forest harvesting managers. Final Report No. 19-87-065. USDA Forest Service, New Orleans, LA. 49 pp.

Ergonomics Applied to Forest Operations

- Smith, L. A., Seay, M. R., and D. L. Sirois, 1985. Evaluation of the effect of heat stress on worker productivity for selected southern forest harvesting tasks. Final Report No. 19-82-082. USDA Forest Service, New Orleans, LA. 40 pp.
- Smith, L. A. and D. L. Sirois, 1982. Ergonomic research: review and needs in southern forest harvesting, *Forest Products Journal*. 32(4): pp. 44-49.
- Smith, L. A. and G. D. Wilson, 1982. Equipment note: an inexpensive system for remote monitoring of work heart rate, *Ergonomics*. 26(7): pp. 719-722.
- Smith, L. A., Wilson, G. D., and D. L. Sirois, (1982). Assessment of the physiological stress of selected forest harvesting activities in the southeastern United States. Final Report No. 19-80-407, USDA Forest Service, New Orleans, LA 128 pp.
- Smith, L. A., Wilson, G. D. and D. L. Sirois, (1983). Work physiology evaluation of southern forest harvesting tasks, *Forest Products Journal*. 33(9): pp. 38-44.
- Society of Automotive Engineers, 1993. Control locations for off-road work machines - SAE J898 OCT87. SAE Handbook Vol. 4. Warrendale, PA. pp. 40.395-40.404.
- Thomas, Robert E. and L. A. Smith, 1991. Reducing back injuries in grapple skidder operators through ergonomic design. Project No. 19-91-033, USDA Forest Service, New Orleans, LA 200 pp.

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ABSTRACTS

Papers presented at the 71st Annual Meeting
Troy State University
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BIOLOGICAL SCIENCES

BACTERIAL CYTOCHROME c552 IS REDUCED BY SULFIDE IN THE GILLS OF THE CLAM LUCINA FLORIDANA.

C. Stephen Powell, Jeannette E. Doeller, and David W. Kraus, Dept. of Biology, Univ. of AL at Birmingham, Birmingham AL 35294.

The clam, Lucina floridana inhabits the sediments of St. Joseph Bay, FL where pore water sulfide levels are approximately $10 \mu\text{M}$. They were collected at sediment depths of 22-45 cm, far removed from grass beds. Optical spectrophotometry of intact gill tissue demonstrated the presence of a functional hemoglobin at $10\text{-}20 \mu\text{M}$. Bacterial cytochrome c552 was also identified at a comparable concentration. Of the total pool of cytochrome c552, 50 - 60% was reduced under anoxic conditions. The remaining 40 - 50% was only reduced under anoxic conditions with the addition of 1 torr hydrogen sulfide (H_2S) and showed reoxidation when H_2S was removed. Thus exposure of excised gills to 1 torr H_2S resulted in further reduction of bacterial cytochrome c552 above that due to endogenous substrates in the absence of oxygen. Supported in part by NSF IBN9118048 to DWK.

DIATOM VALVE ABERRATIONS IN THREE SPECIES IN CONTINUOUS CULTURE. Anne M. Estes and Roland R. Dute, Dept. of Botany and Microbiology, Auburn Univ., Auburn, AL 36849.

Three species of diatoms (Achnanthes brevipes Ag., Nitzschia palea (Kütz.) W. Smith, and Synedra ulna, Ehrenberg) from Carolina Biological Supply Company culture collections were observed using scanning electron microscopy. These cultures had high percentages (87%, 29%, 14% respectively) of morphologically aberrant valves. A direct relationship was noted between years in culture and percent of valves showing aberrations. Aberrant valves were classified as those having displaced, misaligned, or fragmented raphe, an offset stauros, obscured or misaligned punctae, or displaced rimoportulae. Valve lengths were extremely small as compared to those reported in the literature. Restriction of the cytoskeletal system due to exceedingly small cell size is believed to be responsible for morphological malformations.

Abstracts

POLYAMINE LEVELS IN TISSUES OF THE SPINY DOGFISH SHARK, *SQUALUS ACANTHIAS*. Brian K. Gaschen, Stephen A. Watts, and James B. McClintock, Dept. of Biology, University of Alabama at Birmingham, Birmingham, AL. 35294-1170.

Total polyamine concentrations were estimated in the liver, testes, intestine, stomach and spleen of *Squalus acanthias* collected off the coast of Massachusetts in December, 1993. Excised tissues were frozen in liquid nitrogen immediately after collection, and transported on dry ice to UAB. Polyamines were extracted from tissue homogenates by perchloric acid, and the extracts derivitized with dansyl chloride. Concentrations of putrescine, spermidine, and spermine were estimated using HPLC. An unusual pattern of high putrescine relative to low spermidine and spermine concentrations was found in all tissue types, with putrescine/spermine ratios ranging from 3.6:1 in the liver to 17.9:1 in the intestine. The high levels of putrescine found in *S. acanthias* may be related to a high turnover of spermidine, as suggested previously in mouse brain tissue. Spermidine, when conjugated with a bile salt intermediate, comprises squalamine, which exhibits both fungicidal and bactericidal activity. This compound has been found only in *S. acanthias* to date. Consequently, spermidine could be utilized as a precursor for squalamine. Supported in part by NSF EHR-9108767 to J.B.M. and S.A.W.

FLUCTUATIONS IN STEROIDOGENIC CAPACITY IN STOMACH AND GONADAL TISSUES OF *LYTECHINUS VARIEGATUS* IN RESPONSE TO FEEDING. K.M. Wasson, G.A. Hines, J.B. McClintock, S.A. Watts. Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, AL 35294-1170.

During the non-gametogenic stage of the gonadal cycle, *Lytechinus variegatus* were starved for 35 d and then fed *ad libitum* for 32 d. On days 0, 4, 8, 16, and 32 of feeding individuals were sampled, stomachs and gonads were excised and were incubated for 0.5 h with ^3H -androstenedione. Steroid metabolites were suggestively identified by TLC using several solvent systems and product derivitizations. Following starvation, stomach and gonad indices were minimal and microscopic evaluation of gonadal smears did not reveal any developing germ cell populations. During subsequent refeeding, stomach indices increased 4-fold. The percentage of precursor conversion to aqueous and organic soluble products in stomach tissues did not increase significantly. However, the 17β -hydroxysteroid dehydrogenase activity index increased 3-fold while both the 5α -reductase and combined $3\alpha/\beta$ -keto-reductase activity indices decreased. The major steroid metabolite in stomach tissues was testosterone. Gonadal mass did not increase substantially until after day 16, but mass indices remained below 1%. In contrast, the percentage of precursor conversion to aqueous and organic soluble products in gonadal tissues increased ca. 2-fold. The 17β -HSD, 5α -reductase, and $3\alpha/\beta$ -keto-reductase activity indices increased slightly with feeding. The major steroid metabolite of gonadal tissues was testosterone. No sex specific differences in steroidogenic capacity were apparent. Supported by NSF EHR-9108767.

Abstracts

CLONING AND CHARACTERIZATION OF A COLD-INDUCIBLE GENE, *cspS*, FROM *Salmonella typhimurium*. Wee-Yao Ng*, Robert M. Law, and Asim K. Bej. Department of Biology, University of Alabama at Birmingham, Birmingham, AL 35294-1170.

A gene from *S. typhimurium* that encodes for a cold-inducible protein (CSPS) and its upstream regulatory element was cloned in the plasmid vector pCR II by PCR amplification using degenerate oligonucleotide primers designed from the *cspA* gene of *Escherichia coli*. Nucleotide sequence analysis showed that the regulatory element and the gene to be a 0.480 kbp region with CSPS having a molecular weight of 7.4 kDa. The CSPS was found to have 98.6% amino acid homology with the *E. coli cspA* protein. In addition, the upstream regulatory region of *cspS* contains a "fragment 7" region which differs from that of *cspA* by 6 nucleotides. Cold induction of *S. typhimurium* at 4°C in the presence of ^{35}S -Methionine exhibited a significant increase in the production of a 7.4 kDa protein as compared with the protein profile in SDS-PAGE of cells grown at 37°C. The upstream regulatory element together with *cspS* was subcloned into the promoter expression vector pCB 267 creating a protein fusion with β -galactosidase. Comparing clones grown at 37°C with clones grown at 4°C showed a 300-450 fold increased CSPS production as determined using the β -galactosidase assay. This study suggests that the cold-inducible protein may be conserved in many enteric bacteria.

STIMULATION OF ECDYSTEROIDOGENESIS BY SMALL PROTHORACICOTROPIC HORMONE: ROLE OF CALCIUM. G. Chadwick Hayes and R. Douglas Watson, Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, Al 35294.

The secretion of ecdysteroid molting hormones by insect prothoracic glands is regulated by neuropeptide prothoracicotrophic hormones (PTTH). In the tobacco hornworm, *Manduca sexta*, PTTH exists as two size variants, big PTTH (~ 25.5 kDa) and small PTTH (~ 7 kDa). Both size variants employ cAMP as a second messenger; stimulation of ecdysteroidogenesis by big PTTH is calcium-dependent. In the present investigation, prothoracic glands from Day 3 last instar *M. sexta* larvae were incubated *in vitro* in the presence of agents selected to perturb intracellular calcium levels; the effect of the agents on ecdysteroid secretion was determined by radioimmunoassay. Basal ecdysteroidogenesis was not affected by calcium channel blockers (verapamil or lanthanum). Treatment of glands with a calcium ionophore (A23187 or ionomycin) produced a dose-dependent stimulation of ecdysteroidogenesis. Finally, the stimulation of ecdysteroidogenesis by small PTTH was inhibited by a calcium channel blocker (verapamil). The results indicate that basal ecdysteroidogenesis is not calcium-dependent and suggest that small PTTH-stimulated ecdysteroidogenesis is mediated by an influx of calcium.

Abstracts

PROGRESS IN THE MOLECULAR CLONING OF A CDNA ENCODING MOLT INHIBITING HORMONE FROM THE BLUE CRAB CALLINECTES SAPIDUS.

Kara J. Lee, R. Douglas Watson, Stephen A. Watts, and Asim K. Bej, Dept. of Biolgy, University of Alabama at Birmingham, Birmingham, AL. 35294. Terry S. Elton, Dept. of Medicine, University of Alabama at Birmingham, Birmingham, AL. 35294

The secretion of ecdysteroid molting hormones by crustacean Y-organs is regulated by molt-inhibiting hormone (MIH), a peptide produced by neurosecretory cells in eyestalk neural ganglia. To facilitate investigation of the structure and function of MIH, we have initiated studies directed at the molecular cloning of a cDNA encoding MIH from the blue crab, Callinectes sapidus. Polymerase chain reaction (PCR) primers were designed based on the amino acid sequence of MIH from the shore crab, Carcinus maenas. PCR amplification, using cDNA from eyestalks of C. maenas (but not C. sapidus) as template, yielded an amplified fragment of the expected size (approx. 169 base pairs). The PCR-amplified DNA was cloned into a plasmid vector and used for transformation of competent Escherichia coli cells. A Southern blot analysis of EcoRI-restricted plasmid DNA, using an internal oligonucleotide probe, showed specific hybridization to the cloned fragment. DNA sequencing (dideoxy method) revealed a 165 base pair open reading frame corresponding to amino acids 3-57 of C. maenas MIH. A Northern blot analysis using the cloned fragment of the C. maenas MIH gene as probe showed specific hybridization to a single band of RNA from either C. maenas or C. sapidus. These results indicate that the 169 base pair fragment can be utilized as a probe to screen a C. sapidus eyestalk cDNA library. Supported by MS/AL Sea Grant NA16RGO155-03.

POPULATION STRUCTURE OF THE GOPHER TORTOISE (GOPHERUS POLYPHEMUS) IN MOBILE COUNTY, ALABAMA. David H. Nelson, Lisa L. White and I. Suzanne Hatten, Department of Biology, University of South Alabama, Mobile, AL 36688.

Population structures for gopher tortoises were assessed at four locations in Mobile County using pitfall traps. Tortoises were captured, marked and released from June to October, 1993. Data recorded for each specimen included age, sex, body dimensions and weight. Specimens and burrows were measured using tree calipers. Turtles were marked by drilling holes in the marginal scutes. Pitfall traps (13-17) were maintained at each site; they were open for a total of 12 days at each location. There were 109 captures of 48 individual tortoises at the 4 locations. Analysis of all captures revealed a mean carapace length of 24.7 cm (SD=3.74), mean wt of 2912 g (SD=890), and a mean age of 18.2 years (SD=5.97). Recapture rates ranged from 44 to 66% per site ($\bar{X}=56$). A majority of recaptured specimens were encountered 3 times. Sex ratios (M/F) at the four sites ranged from 0.57 to 1.33 ($\bar{X}=0.88$). For females (N=64), capture data revealed a mean carapace length of 25.7 cm (SD=2.90), mean weight of 3179 g (SD=829), and a mean age of 18.4 years (SD=6.20). For males (N=39), the mean carapace length was 24.2 cm (SD=1.56), the mean weight was 2691 g (SD=547), and the mean age was 19.1 years (SD=3.81). Although most specimens captured were adults, two juveniles and one hatchling were encountered.

Abstracts

POTENTIAL HYBRIDIZATION IN CLOSELY-RELATED CRICKET FROG SPECIES: PRELIMINARY RESULTS--DEFINITIVE SPECIES IDENTIFICATION USING ISOELECTRIC FOCUSING. Debra S. Moore, Mickie L. Powell, and Ken R. Marion, Dept. of Biology, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

The genus *Acris* is represented in Alabama by two closely-related species of cricket frogs, *Acris gryllus* and *Acris crepitans*, who share a broad area of overlap in the state. The coexistence of closely-related species requires some type of reproductive isolating mechanism. Many populations of the two species appear to coexist and share the same breeding season, while historically remaining genetically separate. In recent years, however, there are indications of increasing hybridization in the Fall Line Hills region of the state. Morphologically indeterminate individuals have been reported who cannot be placed in either species. To assess the occurrence and the degree of hybridization in these morphologically similar species, a definitive method of identification must be developed. The use of isoelectric focusing for total proteins has provided species-specific banding patterns for the two species. A distinct difference exists between *A. crepitans* and *A. gryllus*. In addition, patterns for *A. gryllus* collected from two different regions of the state remain consistent, decreasing the possibility that the differences reflect geographic variation. This method will be used to aid in the identification of hybrids and the analysis of factors influencing the potential breakdown of reproductive isolation in these two species.

HISTOLOGICAL EVALUATION OF A WHOLE ORGAN EMBRYONIC CHICK PANCREATIC CULTURE SYSTEM. Connie A. Meacham, Nina S. German, Selena S. Williams, and Adriel D. Johnson. Dept. of Biological Sciences, University of Alabama in Huntsville, Huntsville, AL 35899.

Histological studies were conducted using an embryonic chick pancreatic culture system to evaluate time-dependent changes in exocrine tissue. Organ cultures were prepared, using 18-day old embryonic chicks, and were incubated for periods ranging from 2 to 48 hours. After each incubation period, the pancreas was fixed, dehydrated, and embedded; then paraffin sections were prepared histologically using hematoxylin and eosin stains. Histological integrity remained functional with minimal loss of tissue characteristics up to 8 hours of incubation. During the 12 hour incubation period pancreatic lobules revealed localized degenerative changes, structural breakdown of capillary networks within the acinar tissue, and evidence of interstitial edema. After 16, 24, and 48 hours of incubation the pancreas revealed tissue fibrosis, increased tissue separation due to interstitial edema, and loss of organized capillary networks. Cross-sections of the exocrine tissue showed that the peripheral regions remained viable while the centro-lobule acinar tissue appeared progressively non-viable. Additionally, lactate dehydrogenase, an indicator of cellular membrane damage, revealed both non-specific and specific release after 12 hours, which corresponded to the observed histological tissue changes during the incubation periods. There was no observation of total necrosis or atrophy of the exocrine tissue during any incubation time. The histological evaluation indicated that this organ culture system remains functional up to 12 hours before any degenerative processes leading to loss of lobular architecture occurs. Future uses for this system will involve immunohistochemical localization of digestive and pancreatic components; and characterization of digestive pancreatic function in response to various neurotransmitters, hormonal agents, and cholinergic drugs known to alter exocrine function.

Abstracts

COMPARATIVE ASPECTS OF THE POPULATION BIOLOGY OF *LYTECHINUS VARIEGATUS* IN SAINT JOSEPH'S BAY, FLORIDA. Steven D. Beddingfield and James B. McClintock, Dept. of Biology, University of Ala. at Birmingham, Birmingham, AL 35294

Populations of *Lytechinus variegatus* from three discrete shallow-water microhabitats in St. Joseph's Bay are being studied in an ongoing investigation to determine how environmental influences affect individual and population characteristics of the sea urchins at different sites. Sea urchins are feeding on different foods at all three study sites. Differences exist in population densities at the three sites throughout the year. Gonad indices show variations in both the amplitude and number of seasonal peaks between sites. Substantial recruitment of juveniles occurred only at one site (*Thalassia testudinum* seagrass bed) in 1993. Migration of older individuals may be the major influence on density and size frequency at a second seagrass (*Syringodium filiforme*) site. Limited recruitment occurred at a third site characterized by a sand and shell hash substrate. The majority of small (<10mm) juveniles are found in association with adults. Larger juveniles (>10mm and <25mm) are most often found aggregated together in groups of 2-5. Predation on adult sea urchins by seabirds and crabs occurs at all three sites, however low temperatures may be the most important mortality factor for *L. variegatus* in St. Joseph's Bay. Preliminary movement studies indicate that sea urchins found on sand flats have higher movement rates than those inhabiting seagrass beds. Supported by the UAB Department of Biology & NSF EPSCoR grant #EHR 9108761 to J. McClintock.

THE EFFECTS OF NEOTROPICAL PHYTOCHEMICALS ON EXOCRINE PANCREATIC SECRETION. Nina S. German, Adriel D. Johnson, Connie A. Meacham, Robert O. Lawton, Debra M. Moriarity, Dept. of Biological Sciences, William N. Setzer, Dept. of Chemistry, Univ. of Alabama in Huntsville, Huntsville, AL 35899.

Extracts prepared from three tropical plant species, *Didymopanax pittieri*, *Oreopanax xalapensis*, and *Oreopanax oerstedianum*, of the ginseng family (Araliaceae) collected from the Monteverde Cloud Forest Reserve, Costa Rica, exhibit cholecystokinin-A (CCK-A) receptor binding activity. These extracts may serve as probes for elucidation of regulatory mechanisms of gastrointestinal functions. An embryonic chick organ culture system was used to test the effects of these extracts on pancreatic amylase release. Four extract concentrations of 5, 10, 20, and 40 μ l/ml were added to the culture medium. Organ cultures were incubated for 4, 8, 12, and 24 hours in a humidified atmosphere of 5% CO₂ at 37° C. Preliminary data suggests that each extract may stimulate total amylase release and amylase release per unit weight of tissue during the short term incubation time. Identification of natural products which behave as CCK-A agonists or antagonists may be useful in identifying models for new drugs which can serve to treat eating and digestive system disorders. These natural products may also serve as regulators of herbivory and should, therefore be investigated as potentially favorable "satiety drugs" for agricultural use.

Abstracts

RAPID AND SENSITIVE DETECTION OF *Corynebacterium jeikeium* - A CAUSATIVE AGENT FOR BACTERIAL ENDOCARDITIS. Ann Michele Brewer*, Meena H. Mahbubani, Wee-Yao Ng, and Asim K. Bej, Dept. of Biology, Univ. Alabama at Birmingham, AL 35294-1170.

Corynebacterium jeikeium (Group JK) has been identified as an etiologic agent for bacterial endocarditis, especially in patients who have had open heart surgery. Conventional microbiological culture method for the detection of this microbial pathogen is time consuming. Therefore, a genetic-based rapid detection of this pathogen in blood by using polymerase chain reaction DNA amplification method has been developed. A portion of the thymidylate synthase (*ts*) gene from *C. jeikeium* has been cloned in a PCR 1000 plasmid vector by PCR amplification using degenerate oligonucleotide primers that are located within the conserved regions of this gene in other bacterial species and some eukaryotes. Two oligonucleotide primers, LCK-1 and RCJK-1 with T_m values of 76°C and 74°C, respectively, were selected from the deduced nucleotide sequence of the cloned *C. jeikeium* *ts* gene fragment for PCR amplification. Three strains of *C. jeikeium* from ATCC and eight isolates of *C. jeikeium* from patients with endocarditis were PCR amplified with these primers and a 0.288 kbp DNA bands were detected in an agarose gel. None of the non-*Corynebacterium* spp. and non-JK *Corynebacterium* spp. showed positive PCR amplification confirming the specificity of the primers for the target pathogen. Sensitivity of PCR-based detection of *C. jeikeium* was <40 cells per 0.5 ml blood. The PCR-based detection of *C. jeikeium* in blood can be used for routine monitoring and early detection of this pathogen, and possibly other bacterial pathogens, thereby reducing the risk of bacterial endocarditis.

DOLPHIN ANOMALY: FIRST REPORT OF A PYGMY KILLER WHALE (*Feresa attenuata*), IN ALABAMA. Sean P. O'Hare, Department of Biology, Univ. of South Alabama, Mobile, AL 36688. Gerald T. Regan, Department of Biology, Spring Hill College, Mobile, AL 36608.

The partially decomposed carcass of a male, delphinid, cetacean, found on the western end of Dauphin Island, AL, (30 degrees 19.5 minutes North latitude, 88 degrees 13.9 minutes West longitude), was examined, measured, photographed, and the head collected by the authors, on November 30, 1993. The specimen, SHCM200, had a total length >191 cm, and tooth counts were: left upper, 11; left lower, 12; right upper, 10; right lower, 12. The teeth were fully erupted from the gums and had signs of wear, and bones of the skull were well ossified, indicating the animal was beyond neonatal age at death. The flukes and dorsal fin were damaged and there were several shark bites. The tail stock was tapered posteriorly to the peduncle, and the flippers were rounded at the tips. Data and photographs were compared to standard cetacean identification guides, (Leatherwood 1976, Geraci 1993) and correlated well with literature descriptions of *Feresa attenuata*: upper tooth counts, 8-11 each side; lower tooth counts, 11-13 each side; body slender at peduncle; flippers convex on anterior margin and rounded at tips; adult size, 240-270 cm. The patterns of foramina on the maxilla, premaxilla and dentaries, were similar to those observed on TX-C88, an *F. attenuata* skull recovered from a mass, live stranding event, in Port Aransas, TX in 1983. TX-C88 is part of the collection of Texas A and M University in Galveston, TX. The authors gratefully acknowledge the assistance of the volunteers of the Alabama Marine Mammal Stranding Network, Elsa Haubold, and the Texas Marine Mammal Stranding Network.

Abstracts

PI 3-Kinase Involvement in Neurite Outgrowth. Christina R. Burga[^], Andrea Wolf[^], Ira Blader[^], Trevor R. Jackson*, and Anne B. Theibert[^], [^]Neurobiology Research Center, University of Alabama at Birmingham, Birmingham, AL 35294. *AFRC Babraham Institute, Babraham, Cambridge CB2 4AT, UK.

Phosphoinositide 3-kinase (PI 3-kinase) is an enzyme that transfers a phosphate group from ATP to the membrane phospholipids phosphatidyl inositol (PtdIns) and phosphatidylinositol 4,5-bisphosphate (PtdIns-4,5-P₂). Phosphorylation of the phospholipid occurs at the 3-hydroxyl on the inositol head group and the products are PtdIns-3-P and PtdIns-3,4,5-P₃. Recently, this PI 3-kinase and its product PtdIns-3,4,5-P₃ have been intensively studied because of their possible roles as messengers in cell growth and differentiation. Hormones, growth factors, cytokines, and neurotrophic factors activate PI 3-kinase and stimulate the production of PtdIns-3,4,5-P₃ very rapidly after binding to their receptors. Our laboratory is focused on identifying the role of the PI 3-kinase and its product PtdIns-3,4,5-P₃ in neurons. We have examined a well characterized neuronal model cell line, the pheochromocytoma, PC12. PC12 cells respond to nerve growth factor (NGF) with a variety of morphological and biochemical changes. One dramatic morphological response is the outgrowth of processes, called neurites, which resemble axons and dendrites. We have asked the question: is the activation of the PI 3-kinase part of the signal cascade that produces this neurite outgrowth response to NGF. To address this question we have used two methods to block the activation of this enzyme, a chemical inhibitor and transfection of a dominant negative mutant enzyme. In both manipulations, the inhibition of the PI 3-kinase activity results in a dramatic decrease in the neurite response to NGF. This result demonstrates that the PI 3-kinase activation and the resulting increase in PtdIns-3-P or PtdIns-3,4,5-P₃ is an essential molecular component of the neurite outgrowth response.

ACROSIN ACTIVITY OF MURINE SPERMATOZOA. Jan R. Holliday and Gary R. Poirier, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, AL 35294-1170.

Acrosin, a proteolytic enzyme of the mammalian acrosome, has been implicated in a number of fertilization events, including sperm-zona binding, the acrosome reaction and zona penetration. Natural inhibition of acrosin isolated from seminal plasma may regulate acrosin activity during these early events. Because proper functioning of both the enzyme and its inhibitors is crucial to fertilization, an assay that would determine their activity would be useful in predicting the fertilizability of a semen sample. Using BAPNA as a substrate to indicate the amidase activity of murine sperm, it was demonstrated that the activity of acrosin is concentration, time and pH dependent. Furthermore, this enzyme activity is blocked by proteinase inhibitors, including that isolated from the seminal vesicle of mice. This data suggests that murine sperm amidase activity can be readily quantified using a simple spectrophotometric assay.

Abstracts

RAPID AND IMPROVED DETECTION OF *Salmonella* spp. IN ARTIFICIALLY CONTAMINATED CHICKEN USING POLYMERASE CHAIN REACTION (PCR). Sharon M. Graves*, Meena H. Mahbubani, Daniel D. Jones, and Asim K. Bej, Dept. of Biology, Univ. Alabama at Birmingham, AL 35294-1170.

Consumption of foods such as chicken meat contaminated with *Salmonella* spp. can cause enterocolitis, gastroenteritis, and septicemia. A rapid, reliable and sensitive detection of total *Salmonella* spp. and pathogenic *Salmonella* spp. has been developed by a genetic-based primer-mediated Polymerase Chain Reaction (PCR) DNA amplification method. Total *Salmonella* spp. and the pathogenic strains of *Salmonella* spp. were detected by using oligonucleotide primers specific for the *hns* and the *spv* gene segments, respectively. Exponentially growing pathogenic and non-pathogenic *Salmonella* spp. were seeded in 10 g of chicken meat. Following pre-enrichment for 3 h in buffered peptone water (pH 7.2), multiples of 1 ml samples were collected, cells were pelleted by centrifugation; total genomic DNA was released by alkaline lysis; purified with phenol-chloroform-isoamyl alcohol, and precipitated with ethanol. The purified DNA was used directly for PCR amplification. PCR amplification using primers for both *hns* and *spv* targets simultaneously generated DNA bands of molecular weights of 0.152 and 0.247 kbp, respectively. Sensitivity of PCR-based detection for both pathogenic and non-pathogenic strains of *Salmonella* spp. was <10 cells in 10 g of artificially contaminated pre-enriched chicken meat samples. The entire detection method takes approximately 8 h. This rapid and sensitive PCR-based simultaneous detection of total *Salmonella* spp. and pathogenic strains of *Salmonella* spp. can be used for routine monitoring of meat samples, thereby reducing the risk of disease outbreaks.

Some electrical characteristics of tomato seedlings: IV. Effect of mechanical injury. B. Edwards, J. Reeves, R. Lee and C. Olander. Department of Biology, Jacksonville State University, Jacksonville AL 36265.

Using a common variety of tomato, electrical activity was recorded from electrodes implanted in the stem after varying degrees of mechanical injury(i.e. pinching with plastic or metal tweezers cutting with plastic or metal scissors or cutting with a blade.). The types on responses their duration and amplitude will be described. Mean values of the amplitude and conduction velocities of these potentials in response to mechanical injury is reported. Data typically obtained will be presented. It was noted that the excitability level between similar plants on the same day and in the same plant on different days is variable and undergoes periodic changes.

Abstracts

DETECTION OF MULTIPLE MICROBIAL PATHOGENS IN ARTIFICIALLY CONTAMINATED OYSTER MEAT USING POLYMERASE CHAIN REACTION (PCR). Lynn Beasley*, Daniel D. Jones, and Asim K. Bej, Dept. of Biology, Univ. Alabama at Birmingham, AL 35294-1170.

A rapid and sensitive method for simultaneous detection of *Salmonella* spp. and *Vibrio* spp. in seafood has been developed involving multiplex PCR DNA amplification and gene probe hybridization. Oysters were seeded with < 10-10⁶ cells of each of the following species: *Salmonella typhi*, *Salmonella typhimurium*, *Vibrio cholerae*, *Vibrio parahaemolyticus*, and *Vibrio vulnificus*. The oyster meat samples were processed with 18% Chelex™ 100 and 2.5 M NH₄OAC, and purified with chloroform:isoamyl alcohol. The supernatant from each oyster meat sample consisting of DNA from target microorganisms was further purified and concentrated in a microconcentrator. Multiplex PCR amplification of each of the purified samples was performed simultaneously using five sets of primers specific for the *hns*, *spvB*, *ctx*, *tl* and α -hemolysin gene in *S. typhi*, *S. typhimurium*, *V. cholerae*, *V. parahaemolyticus*, and *V. vulnificus*, respectively. The multiplex PCR amplification was optimized using variable molar quantities of each set of primers and 4mM MgCl₂. After amplification, the amplified DNAs were analyzed by their molecular weights using agarose gel electrophoresis. The amplified DNAs from the processed oyster meat, which were contaminated with these microbial pathogens, were detected at a sensitivity of <10 cells per pathogen. Detection takes <36 hours and is useful for epidemiological survey, distribution, source, identity and routine monitoring for these pathogens in contaminated shellfish and other seafood.

VARIATION AMONG NORTHEASTERN ALABAMA POPULATIONS OF *LINDERNIA* ALL. James T. Tipton and Jeri W. Higginbotham, Dept. of Biology, Jacksonville State University, Jacksonville, AL 36265.

Four populations of *Lindernia* All. from northeastern Alabama were examined electrophoretically to determine the extent of differentiation among putative *Lindernia saxicola* Curtis and *L. monticola* Muhl. ex Nuttall relative to *L. dubia* (L.) Pennell. Leaf measurements of field collected specimens were taken as well. Eight enzyme systems were assayed. Populations exhibited apparent fixed heterozygosity for many enzymes. Variation of enzyme phenotypes was partitioned among populations with little to no variation observed within populations. Leaf measurements, also, varied more among populations than within populations. These results are consistent with the population structure expected of a predominantly self-pollinating species with widely disjunct populations. The conclusion that *L. saxicola* is a distinct species cannot be made from our results.

Abstracts

SPECIES-SPECIFIC IDENTIFICATION OF *Escherichia coli* BY POLYMERASE CHAIN REACTION (PCR) FOR MONITORING DRINKING WATER QUALITY. Jon P. Southworth* and Asim K. Bej, Dept. of Biology, Univ. of Alabama at Birmingham, Birmingham, AL 35294-1170.

Routine monitoring of *Escherichia coli* as an indicator microorganism for fecal contamination of drinking and potable waters is required by Federal agencies for protection of public health. Previously, PCR methods using oligonucleotide primers that amplified a 0.147 kbp segment of the *uidA* gene were used as an alternate approach for detection of *E. coli* in water. However, these primers also amplified DNA of all *Shigella* spp. The 0.147 kbp segment of the *uidA* gene from *E. coli*, *Shigella sonnei*, *S. flexneri*, *S. dysenteriae*, and *S. boydii* were cloned and sequenced. Comparisons of the nucleotide sequences between *E. coli* and *Shigella* spp. showed a mismatch nucleotide of the 3'-end of the upstream primer, and a new primer incorporating this mismatch was designed. Another primer was selected further down stream of this gene segment. PCR DNA amplification using these primers generated 0.927 kbp DNA fragment from *E. coli*, *S. sonnei*, and *S. flexneri*, but no amplification was seen in *S. boydii*, or *S. dysenteriae*. With elimination of two strains of *Shigella* spp., the 0.927 kbp DNA fragment from the *uidA* gene were subsequently cloned and sequenced in order to investigate other possible mismatched nucleotides in the *uidA* gene between *E. coli* and *Shigella* spp. Primers will be designed based on the 3'-end mismatched site, and tested for amplification of *E. coli* DNA without any amplification of *Shigella* strains. PCR-based assay using these oligonucleotide primers for the amplification of a segment of the *uidA* gene will provide an alternate method for specific detection of *E. coli* as an indicator microorganism for water quality monitoring.

Some electrical characteristics of tomato seedling : I. Spontaneous electrical activity and electrode placement. C. Olander, R. Lee, P. Jacobsen, G. Brown and M. Stanfield. Department of Biology, Jacksonville State University, Jacksonville AL 36265.

Electrical activity in plants has been known for over one hundred years, but its physiologic function or underlying molecular mechanism is still not well understood. It is assumed that electrical activity in plants (ie. action potentials, variation potentials and voltage transients) can be a mechanism both for signal transmission and for the regulation of various physiologic processes both at the molecular and whole organism level. The use of digital data acquisition devices with computer storage has greatly facilitated the analysis of these electrical events. The set up and use of computers, the types and placement of recording electrodes and their effect on the recordings of spontaneous electrical activity of tomato seedlings will be demonstrated. Upward and downward conduction with various electrode placement are compared. It was noted that the excitability level between similar plants on the same day and in the same plant on different days is variable and undergoes periodic changes.

Abstracts

SELECT POPULATION PARAMETERS OF A THREATENED SPECIES,
CYPRINELLA CAERULEA (JORDAN), IN THE LITTLE RIVER DRAINAGE.
Terri L. Dobson, Department of Biology, Jacksonville State
University, Jacksonville, AL 36265.

This study of *Cyprinella caerulea* (Jordan) is part of a study of the fishes of Little River Drainage in northeast Alabama (September 1992 to the present). Little River is one of only two watersheds in Alabama that this species is known to be found, the other being Choccolocco Creek. In this study, a range extension in Little River has been documented. This new record is located 3.7 km upstream of the last known record which was made by J. Malcolm Pierson in 1982. The blue shiner is known to occur in the lower 6.5 km of main channel habitat in Little River between the new record location and Alabama Highway 273. It is commonly collected with *Campostoma oligolepis*, *Cyprinella callistia*, *Notropis stilbius*, *Hypentelium etowanum*, *Lepomis auritus*, *Percina nigrofasciata*, *Percina palmaris*, and *Etheostoma jordani*. The monthly number and standard length of the blue shiners at Station one of the study have been recorded. Length frequency distributions and mean monthly length have been calculated as well as percent relative abundance of this species in relation to other species of fishes found with the blue shiners in this study. The blue shiners seem to prefer a habitat with cool, slow-moving water, nearby vegetation, and a sand-rock substrate. This project was supported in part by a grant from the Theodore Roosevelt Memorial Fund of the American Museum of Natural History.

TORUS STRUCTURE AND FUNCTION IN BOTRYCHIUM DISSECTUM, THE COMMON GRAPE FERN. Angela C. Morrow and Roland R. Dute, Dept. of Botany and Microbiology, Auburn Univ. Auburn, AL 36849.

Tracheary elements in most gymnosperms and a few angiosperms contain torus-bearing pit membranes. The torus is a circle of impermeable wall material surrounded by a permable pit membrane (the margo). In the presence of an air embolism, the pit membrane is aspirated and the torus blocks the pit aperture thus confining the air bubble. A torus and a half torus (between tracheid and parenchyma cell) were identified in 1920 from light microscopic studies of the fern genus Botrychium. We have confirmed the presence of the torus and half torus in Botrychium dissectum using transmission electron microscopy. Immediately after maturation (death) of the associated tracheid, matrix material is lost from the margo. With time the amount of matrix material within the torus decreases, and it loses its electron-opaque appearance. The amount of hydrolysis and the manner in which it occurs is not uniform in this fern. The half torus develops on the tracheid side of a blind pit adjacent to a parenchyma cell. When the tracheid is mature, the margo region facing the tracheid loses its matrix material, but the hydrolysis does not extend through the adjoining wall of the parenchyma cell. Studies are underway to determine those subcellular structures associated with torus ontogeny.

Abstracts

MOLECULAR SEROTYPING OF PATHOGENIC *Escherichia coli* USING ARBITRARILY-PRIMED POLYMERASE CHAIN REACTION (AP-PCR). Patrick W. Lett*, Daniel D. Jones, and Asim K. Bej. Department of Biology, University of Alabama at Birmingham, Birmingham, AL 35294-1170.

Recent outbreaks of food poisoning associated with *Escherichia coli* have increased public concern about the safe consumption of red meats. As a result, there has been increasing pressure put on regulatory agencies to improve monitoring techniques for the detection of these bacterial pathogens. A desirable detection method would not only be able to detect the presence of *E. coli*, but would also be able to discriminate among the various strains of pathogenic *E. coli*. We have examined the use of AP-PCR in generating DNA fingerprints characteristic of various pathogenic *E. coli* serogroups, thereby allowing for detection and discrimination among pathogenic *E. coli* strains. AP-PCR is characterized by the use of a single, relatively small (10-20 nt), randomly designed oligonucleotide primer in the PCR reaction, as opposed to conventional PCR where a pair of primers is designed to match a particular DNA target. We used an arbitrary primer (RPSE) 16 nt long to generate DNA fingerprints for eight *E. coli* serotypes that were representative of non-pathogenic, enteropathogenic, enteroinvasive, and enterohemorrhagic *E. coli* classifications. Our results showed that AP-PCR generated unique DNA fingerprints that were effective in both the detection of pathogenic *E. coli* as well as the identification the particular strain as belonging to a specific serotype. The AP-PCR approach of detecting and differentiating various pathogenic strains of *E. coli* will facilitate epidemiological studies, as well as improve medical diagnosis.

VITELLOGENESIS IN THE BLUE CRAB, *CALLINECTES SAPIDUS*: *IN VITRO* STUDIES OF VITELLIN SYNTHESIS. Chi-Ying Lee and R. Douglas Watson, Dept. of Biology, Univ. of Alabama at Birmingham, AL 35294-1170.

To determine the sites of yolk protein synthesis in the blue crab, *Callinectes sapidus*, tissues (ovary, hepatopancreas, gill) from adult female crabs were incubated *in vitro* with [³⁵S]methionine. Tissue extracts were separated by SDS-PAGE and radiolabeled proteins visualized by autoradiography. Two proteins (109 and 86 kDa) synthesized by the ovary co-migrated with the major subunits of vitellin (Vn). A Western blot analysis confirmed the proteins were Vn-immunoreactive. Proteins from hepatopancreas and gill were not immunoreactive. *In vitro* incorporation of [³⁵S]methionine into ovarian proteins was inhibited by an extract of eyestalks; the inhibition was dose dependent and tissue specific. Autoradiography of the electrophoretically separated ovarian proteins revealed the eyestalk extract inhibited incorporation of [³⁵S]methionine into most proteins, including the major Vn subunits. The results suggest that the ovary is a site of Vn synthesis, and that the eyestalks contain a factor or factors that directly inhibit the synthesis of Vn and other ovarian proteins. Supported in part by AAS and MS/AL Sea Grant NA16RG0155-03.

Abstracts

BIOLOGICAL CONTAINMENT OF GENETICALLY ENGINEERED MICROORGANISMS USING A CONDITIONAL SUICIDE SYSTEM. Sharon M. Graves^{1*}, Wee-Yao Ng¹, Søren Molin², and Asim K. Bej¹, ¹ Dept. of Biology, Univ. Alabama at Birmingham, Birmingham, AL 35294-1170; ² Dept. Microbiology, The Technical University of Denmark, DK-2800, Lyngby, Denmark.

A conditional suicide genetic system using the staphylococcal and the *Serratia* nuclease genes (*st-nuc* and *sr-nuc*, respectively) under the control of $P_{lacZ'}/O/lacI^R$ and $P_{Tr}/lacO/lacI^R$ has been constructed in pSE420 and pSM1088 plasmid vectors for containment of genetically engineered microorganisms (GEMs) released in the environment. These plasmid constructs were tested in *Escherichia coli* for their killing efficiencies of the host strain upon induction, and it has been found that the *st-nuc* is more effective than the *sr-nuc*. The *st-nuc* was further tested in a number of enteric bacterial species such as *Enterobacter cloacae*, *Hafnia alvei*, and *Salmonella typhimurium*. Viable plate counts on the DNase test agar following induction indicated the lethal effect of the nuclease gene in the host cells. In *E. coli*, the kinetics of the *st-nuc* induction showed reduction of initial cell number from 3×10^4 to < 1 cell per ml within first 1 h. In other enteric bacterial species, the lethal effect of the *st-nuc* expression caused a 3-fold reduction in cell number within the first 3 h of induction. Currently, the use of this "built-in" self-destruct genetic system in GEMs that are capable in degrading xenobiotics is being tested in soil microcosms. Following completion of their intended functions, the microbial conditional suicide genetic system has the potential to reduce the risk of long term persistence and possible adverse effects of GEMs which are deliberately or accidentally released into the environment.

THE USE OF OXYGEN FLUX MEASUREMENTS TO DETERMINE GROWTH EFFICIENCIES FOR HATCHLING AUSTRALIAN CRAYFISH, *Cherax quadricarinatus*, AT DIFFERENT TEMPERATURES AND SALINITIES. Mark E. Meade and Stephen A. Watts. Univ. of Ala. at Birmingham, UAB Station, Birmingham, AL 35294.

The Australian freshwater crayfish, *Cherax quadricarinatus*, inhabits many areas in which temperature and salinity fluctuations occur. Studies using newly hatched crayfish in the 10-15 mg fresh weight size class were initiated to examine the effects on growth and metabolism at temperatures ranging from 12 to 36°C and salinities ranging from 0 to 30ppt. After ten weeks in freshwater, optimal growth was observed at 28°C with hatchlings averaging 922.8 ± 93.3 mg fresh weight. Above and below this temperature, growth was reduced before reaching the lethal limits of survival at 34 (LT50_{13d}) and 12°C (LT50_{12d}). Reduced growth was also observed at increasing salinities before reaching a lethal limit (LC50_{7d}) of 25ppt salinity at 28°C. Metabolic rates (oxygen flux) were temperature-dependent, with rates increasing as temperature increased over the range of 20 to 32°C. Metabolic rates did not appear to differ with acclimation to different salinities in the 0 to 20ppt range. Calculated growth efficiencies (growth rate/oxygen flux) demonstrate optimal conditions for growth in the 26-28°C range and Oppt salinity, suggesting maximal rates of growth relative to energy utilization. We hypothesize that similar growth efficiency measurements can be used to assess the optimal growth potential of *Cherax quadricarinatus* as well as other crustacean species under a variety of environmental conditions.

Abstracts

SYNTHESIS OF A NOVEL ANDROGENIC METABOLITE IN THE TESTES OF TILAPIA. Adam B. Keeton, Gene A. Hines and Stephen A. Watts. Dept. of Biology, Univ. Alabama at Birmingham, Birmingham, AL 35294-1170.

Previous studies have shown that, among the vertebrates, 11-oxygenated androgen derivatives are produced predominately by teleost species. For example, the steroid 11-ketotestosterone is thought to be the major androgen regulating salmonid reproductive physiology. We have initiated a series of studies to evaluate the major androgens produced in tilapia. Testicular minces from reproductively mature *Oreochromis niloticus* x *O. aureus* were incubated with ³H-androstenedione as a precursor for 0.25, 1 and 4 h in order to determine steroidogenic capacity. The resulting metabolites were identified utilizing thin layer chromatography with several organic solvent systems and chemical derivitizations. Androstenedione was converted into a variety of steroid products typical of teleosts, including testosterone and 5 β -reduced androgens. Further, approximately 30% of the precursor was converted into water soluble steroid conjugates within 4 h. We have tentatively identified a seemingly novel metabolite, which appears to be related to the 11-oxygenated androgens based on its relative chromatographic mobility, but it is not 11-ketotestosterone. This compound is often the major steroid produced by tilapia testes and may represent an alternative androgen involved in regulating the physiologically significant androgenic pool in fish. Supported by the Environmental and Applied Aquaculture Institute.

ANTIGENIC DETERMINANTS OF SALMONELLA TYPHIMURIUM OMPC PORIN. Shree R. Singh 1, Yvonne U. Williams 1, Phillip E. Klebba 2, and Shiva P. Singh 1. 1. Alabama State University Montgomery, AL 36101, 2. Medical College of Wisconsin, Milwaukee, WI 53226.

Salmonella typhimurium OmpC porin was isolated from SH 7457. The monomer was subjected to CNBr-TFA cleavage SDS-Electrophoresis of CNBr peptides revealed eight bands when visualized by silver staining. CNBr fragments were electrophoresed and transferred to PVDF membrane. The N-terminal sequencing was performed using a pulse phase sequencer. The results of these analyses indicated high homology with S. typhi sequence. CNBr peptides were screened in western immunoblot with anti-OmpC MAbs. All of these MAbs reacted with monomer antigen. Nine MAbs were specific for buried epitopes and three for cell surface epitopes. These MAbs recognized five antigenic regions within the regions of CNBr fragments. It appears that S. typhimurium like other gram-negative bacteria contains several beta strands. The antigenic sites recognized in this study can be effectively used to immunize the animals against Salmonella and other gram-negative bacteria.

Abstracts

ALLOZYME VARIATION WITHIN AND AMONG POPULATIONS OF GOPHER TORTOISES (*GOPHERUS POLYPHEMUS*) IN SOUTHERN ALABAMA. Susannah T. Williams and Terry D. Schwaner, Alabama School of Mathematics and Science, Mobile, AL 36604. David H. Nelson, Dept. of Biology, Univ. of S. Ala., Mobile, AL 36688. Craig Guyer, Dept. of Zoology and Wildlife Science, Auburn Univ., Auburn, AL 36849.

Blood samples from 40 (captured and released) Gopher Tortoises, representing five isolated populations, 4 in Mobile Co. and one in Escambia Co., AL, were surveyed for one non-enzymatic and 19 enzymatic proteins, representing 22 presumed genetic loci, using Cellogel and starch gel electrophoresis. Five loci were polymorphic, each with two different alleles. Frequencies of alleles for polymorphic loci varied among populations, with fixation or near-fixation of alternate alleles in some samples. Although small (6-12 individuals), sample sizes represented 40-82% of the estimated numbers of tortoises in each population. A log-likelihood analysis falsified the null hypothesis of no difference in observed and expected allele frequencies among populations for four loci. A dendrogram constructed from Nei's unbiased index of genetic similarity closely grouped the Mobile Co. populations separate from the Escambia Co. tortoises. Genetic differences between the Mobile Co. and Escambia Co. populations were related to their distance and separation by the Alabama River. These results are similar to those obtained in a previous study of the Western Gopher Tortoise (*G. agassizi*). However, low amounts of detectable variation in tortoise populations, generally, and in our samples, specifically, suggested that more meaningful insights into the genetics of the species in Alabama will require a more direct analysis of their DNA.

PRELIMINARY POPULATION STUDIES OF THE BLACK LAND CRAB, *GECARCINUS LATERALIS*, ON SAN SALVADOR ISLAND, BAHAMAS. Ken R. Marion and James B. McClintock, Biology Dept., Univ. of Alabama at Birmingham, Birmingham, AL 35294-1170.

Little is known concerning the population dynamics and demographic structure of the black land crab, *Gecarcinus lateralis*. This Caribbean burrowing species is highly territorial. We conducted a preliminary demographic study on San Salvador Island, Bahamas, during June, 1993. The study site was a strip of open shrub-brush habitat with sandy substrate running parallel to and within 50 m of the beach. Sherman small mammal traps were baited with sardines and placed in pairs at 9 m intervals along a transect. Each pair was 2 m apart. Traps were checked and rebaited every morning and evening. Captured crabs were individually marked with indelible ink and released. The Schnabel formula for estimation of population size indicated a density of 0.23 crabs/m². Nearly all recaptures occurred in the same trap. Captured crabs showed a sex ratio of 9M:1F. The impending egg-laying season may have influenced sex ratios. This study will be continued for several years to determine temporal changes in population dynamics.

Abstracts

EXPRESSION OF ZETA-PROTEIN KINASE C IN CENTRAL NERVOUS SYSTEM DEVELOPMENT. Starla E. Hunter, Michael L. Seibenhener, and Marie W. Wooten, Dept. of Zoology, Auburn University, Auburn, AL 36849

The developmental expression of the atypical protein kinase C (PKC) isoform, zeta (ζ) was examined in rat brain. Western blot analysis using affinity purified isoform specific antisera to ζ -PKC revealed peak expression at both 4 da pre-birth and 2-3 da post-birth. In adult rat brain ζ -PKC was enriched in cerebellum, while both thalamus and cerebellum displayed immunoreactivity in the developing brain. Differential sucrose gradient centrifugation was employed to examine the subcellular distribution of ζ -PKC in developing brain. Equal distribution was observed between cytoplasm and membrane fractions, while the growth cone fraction was enriched in ζ -PKC. Endogenous substrate proteins were characterized in the subcellular fractions. Several specific substrates were localized in the growth cone fraction: pp70, pp60 doublet, pp50 and pp45. Our findings reveal a unique developmental expression pattern for ζ -PKC in brain compared to other PKC isoform proteins and suggests that ζ -PKC may function in neuronal differentiation. Supported by Auburn University Howard Hughes Life Sciences Scholar's Program (SEH).

HEMIDACTYLUS spp. (SAURIA: GEKKONIDAE), A PRELIMINARY SURVEY OF POTENTIAL GENETIC MARKERS TO DISTINGUISH FOUR EXOTIC, INTRODUCED SPECIES IN THE SOUTHEASTERN UNITED STATES.

C. Lockett Allbritton and Terry D. Schwaner, Alabama School of Mathematics and Science, Mobile, AL 36604. Brian Butterfield, Dept. of Zoology and Wildlife Science, Auburn Univ., Auburn, AL 36849. Richard Thomas, Dept. of Biology, Univ. of Puerto Rico, Rio Piedras, PR 00931.

Allozyme electrophoresis on Cellogel was used to survey four species of geckos, genus Hemidactylus (H. turcicus, H. mabouia, H. frenatus and H. garnotii), all exotic introductions into the Southeastern United States. Thirteen presumed genetic loci representing 11 enzymatic proteins were clearly detected and scored for two to five individuals of each species. Fixed allelic differences (frequencies = 1.00) between all four species were found at 8 loci (PEP A, PEP C, PEP D, PK, MPI, CA, IDH1 and IDH2). Fixed allelic differences for PEP B distinguished H. turcicus and H. mabouia; similarly, AAT and ME distinguished the latter two species and H. garnotii. H. garnotii had a unique allele for 6PGD. Several other loci (MDH, ADH, GPI, and PGM) that were too difficult to score on Cellogel may distinguish these taxa on starch gels. Identification of these morphologically similar species is facilitated (if tissues are available for comparisons) by electrophoretic examination of their enzymatic proteins.

Abstracts

HERPETOFAUNAL SURVEY OF LITTLE RIVER CANYON IN ALABAMA.
Melissa J. Dunaway, Dept. of Biology, Jacksonville St.
Univ., Jacksonville, AL 36265.

Little River Canyon has recently been designated a national preserve by the National Park Service. With no formal surveys in northeastern Alabama, there is a need for baseline data. Due to the ruggedness of the terrain, several collection methods were utilized. Five sites were visited every month for one year, during the day and night. Tributaries into the canyon were also explored. Twenty-six species of amphibians were found, including one of special concern, the green salamander (Aneides aeneus); this was about 87% of the expected species of the area. Twenty-seven species of reptiles were found. This was only 59% of the expected species. Only 36% of the expected snake species were found. This may be due to the low small-mammal diversity, extermination by local residents, and sampling biases. The most common species were Fowler's toad (Bufo woodhousei fowleri), American toad (Bufo americanus), two-lined salamander (Eurycea cirrigera), green anole (Anolis carolinensis), and Eastern fence lizard (Sceloporus undulatus). Although herptiles can be found all year, seasonal observations show that summer was the peak season, with May, June, and July being the peak months. Seasonal abundances were compared across related taxa.

Comparison of Procedures for Total Protein Determination of Plant Tissues—Christy Cox & Wayne Shew, Dept. of Biology, BSC, Birmingham, AL 35254—A variety of procedures are used for the determination of total protein content in plant tissues. However, some of these procedures give falsely high protein concentration values because of their reactivity with phenolics which are prevalent in plant tissues. We compared four procedures commonly used in total protein determination; Biuret, Bicinchoninic Acid (BCA), Bradford, and Lowry. We wanted to determine which of these would be least sensitive to phenolic and other nonprotein compounds and thus give a more accurate measure of total protein content in plant tissues. Leaves from six species of plants were used as samples in the investigation: Vaccinium sp., Lactuca sp., Vitis sp., Brassica olearacea, Cakile constricta and C. edentula. The samples were ground in 0.15M phosphate buffer using a mortar and pestle and then centrifuged to remove sand and large pieces of debris. The supernatant was removed, diluted appropriately and the total protein content determined using each of the four procedures listed above. In addition to testing these plant tissues, the phenolic compounds eugenol, guaiacol, and pyrocatechol as well as several free amino acids (alanine, phenylalanine, tyrosine) were tested using these procedures. Our findings indicate that Bradford is least sensitive to the presence of phenolic compounds and is the assay procedure of choice for total protein determination in plant tissues. The popular BCA assay gave results similar to the Lowry procedure and should not be used routinely in total protein determination of plants.

Abstracts

EXPRESSION AND IMMUNOGENICITY OF PHASE-SPECIFIC 44-KILODALTON ONCO-FETAL ANTIGEN ON RODENT AND HUMAN FETAL AND TUMOR CELLS. Shirley D. Rohrer, Division of Natural Science, Mobile College, Mobile, AL 36663. Raymond B. Hester, Adel L. Barsoum, James W. Rohrer and Joseph H. Coggin, Jr., Dept. of Microbiology and Immunology, Univ. of South Alabama College of Medicine, Mobile, AL 36688.

Oncofetal antigen (OFA) is a conserved, tumor and fetal tissue-restricted, cell surface-associated auto-immunogen. OFA is expressed in a phase-specific manner during normal rodent fetal development (as demonstrated by the decreased immunogenicity of late gestation fetal cells in cell-mediated tumor challenge assays), and is absent from normal adult tissue. An IgM monoclonal antibody to OFA (MoAb 115), developed by the immunization of adult mice with midgestation fetal cells from primiparous, syngeneic pregnancies, or a control antibody was used in an indirect immunofluorescence assay to determine OFA expression as measured by flow cytometry. Microscopic cell inspection revealed typical rimmed fluorescence. OFA was demonstrated on 9 and 13 day gestation murine fetal cells and on WI-38, a human embryo cell line, but was greatly diminished on term murine fetal cells. Adult thymocytes did not express significant OFA. The vast majority of tumor cell lines tested expressed significant OFA regardless of their initial method of induction--chemical, viral or radiation or of their tumor cell type. In murine radiation-induced thymic lymphoma, OFA expression preceded clear histologic evidence of malignant T-cells or clinical symptoms. T-cell clones, specifically reactive to purified OFA, were generated from mice following immunization with syngeneic thymic lymphoma cells or fibrosarcoma cells.

Rudbeckia auriculata (Perdue) Kral: ITS STATUS AND DISTRIBUTION. Alvin R. Diamond, Jr., and Terry W. Owens, TSU Arboretum, Troy State University, AL 36082.

Rudbeckia auriculata (Perdue) Kral, is a perennial herb in the Aster family confined to permanently moist sites. It was originally described as a species in 1975, and is restricted in its distribution to seven Alabama counties. Six of these counties are in the Coastal Plain Province and the other is in the Ridge and Valley Province. Extensive searches have failed to locate additional populations either in Alabama or adjacent areas of Florida and Georgia. A total of seventeen individual populations are known. Most populations consist of less than twelve flowering stems, and occur on roadside or powerline right-of-ways. Threats to the continued existence of Rudbeckia auriculata (Perdue) Kral include construction, the use of herbicides, habitat conversion, poor seed formation, and lack of seedling recruitment. It is recommended that this species be raised from C3 to threatened status by the U.S. Fish and Wildlife Service.

Abstracts

SEXUAL DIMORPHISM OF BOX TURTLES (TERRAPENE CAROLINA): A MORPHOMETRICAL ANALYSIS. Jeffrey T. Dunaway, Dept. of Biology, Jacksonville St. Univ., Jacksonville, AL 36265.

Sexual dimorphism has been noted in box turtles for eye color, claw length, tail size, and presence or absence of concavity of the plastron. While clutch size is related to body size in many reptiles, the strength of this relationship is not as strong in turtles. Natural selection may tend to favor larger body size in females to accommodate larger clutches of eggs. On the other hand, territorial behavior in males may favor larger body sizes in that sex. This study investigates morphometric variation in male and female box turtles from Alabama. Preliminary results indicate that there are no differences between males and females in carapace length, carapace width, carapace height, and total volume (t-test, $p>0.05$). Comparison of the height of the anterior and posterior portions of the carapace indicate no differences between sexes (t-test, $p>0.05$). The posterior portion of the carapace of females is higher than the anterior portion, while in males, the anterior portion is higher than the posterior portion (t-test, $p>0.05$). This suggests that the rear portion of the box turtle shell in females to accommodate eggs. These data are preliminary but they do suggest some interesting evolutionary trends.

SOYBEAN: EARLY ENDOSPERM DEVELOPMENT, ENDOSPERM FAILURE. Roland R. Dute and Curt M. Peterson, Dept. of Botany and Microbiology, Auburn Univ., Auburn, AL 36849.

Normal endosperm development within the soybean ovule begins with the process of double fertilization; the fertilized egg becomes the embryo, and the primary endosperm nucleus becomes the endosperm. The primary endosperm nucleus undergoes a series of mitoses to form a free-nuclear phase. Accompanying this process is a loss of starch and increased vacuolation in the endosperm cytoplasm. The cytoplasm at this stage is metabolically active. Transfer wall ingrowths increase in number along the lateral walls of the central cell as well as at the chalazal region. Endosperm cellularization first occurs when the globular embryo proper is distinct from the suspensor. Cellularization begins at the micropylar end of the central cell as anticlinal walls projecting into the endosperm cytoplasm from the central cell wall. Vesicles, microtubules, and endoplasmic reticulum are associated with the growing ends of these walls. Periclinal walls, initiated as cell plates during mitosis, complete the cellularization of parts of the endosperm. Instances exist where no fertilization or only single fertilization (of the egg) occurs. These ovules abort at an early stage. During single fertilization the fertilized egg develops into a proembryo but goes no further. Such instances prove that a properly functioning endosperm is necessary for continued embryo development.

Abstracts

INTRACELLULAR EXPRESSION OF THE STAPHYLOCOCCAL NUCLEASE GENE IN *Escherichia coli*. Wee-Yao Ng*, Sharon Graves, Søren Molin, and Asim K. Bej. Department of Biology, University of Alabama at Birmingham, Birmingham, AL 35294-1170.

The staphylococcal nuclease gene without its signal sequence (*nuc-Δs*) was cloned under the control of $P_{T7}/lacO/lacI$ and $P_{lac}/lacO/lacI^R$ in the plasmid vectors pET24d and pSE420, respectively following PCR amplification of *nuc-Δs*. The *nuc-Δs* cloned in pET24d and pSE420 showed a 5 amino acid insertion after the ninth amino acid residue and a point mutation causing a transition from an Adenine to a Guanine on the 43rd and 146th nucleotide positions. Computer analysis of the mutated *nuc-Δs* did not show any alteration of the predicted active sites of the staphylococcal nuclease (SNUC). Induction of clones with IPTG did not show any extracellular expression of SNUC on DNase test agar plates. Upon induction, intracellular expression of SNUC was detected by Western Blot analysis. Intracellular stability of SNUC in the clones was up to 2 h as determined by ELISA assay. The insertion and point mutations did not seem to alter the intracellular enzymatic activity of SNUC. Following induction, the clones showed a decrease in cell number from 1.0×10^6 to <1 cell per ml within the first 2.5 h. Retention of wild type SNUC activity intracellularly in the mutated SNUC could help to understand the regulation of genes that code for extracellular proteins, particularly in *Staphylococcus aureus* and possibly other pathogenic bacteria.

DIATOM VALVE ABERRATIONS IN THREE SPECIES IN CONTINUOUS CULTURE. Anne M. Estes and Roland R. Dute, Dept. of Botany and Microbiology, Auburn Univ., Auburn, AL 36849.

Three species of diatoms (Achnanthes brevipes Ag., Nitzschia palea (Kütz.) W. Smith, and Synedra ulna, Ehrenberg) from Carolina Biological Supply Company culture collections were observed using scanning electron microscopy. These cultures had high percentages (87%, 29%, 14% respectively) of morphologically aberrant valves. A direct relationship was noted between years in culture and percent of valves displaying aberrations. Malformations in aberrant valves (depending upon species) included: displaced, misaligned, or fragmented raphe, an offset stauros, obscured or misaligned punctae, or displaced rimoportulae. Valve lengths were extremely small as compared to those reported in the literature. Restriction of the cytoskeletal system due to exceedingly small cell size is believed to be responsible for morphological malformations.

TEACHING SENSITIVE SUBJECTS--PROSTITUTION. Lyle L. Shook, Dept. of Justice and Public Safety, Auburn Univ. at Montgomery, Montgomery, AL 36117-3596.

Prostitution, for some people, is a sensitive subject. This paper presents the results of teaching a new Scholars course at AUM about prostitution.

Abstracts

TUMOR ANTIGEN SPECIFICITIES OF T CELL CLONES DERIVED FROM TUMOR-IMMUNE MICE. Shirley D. Rohrer, Dept. of Life Sciences, University of Mobile, Mobile, AL 36663. James W. Rohrer, Adel L. Barsoum and Joseph H. Coggins, Jr., University of South Alabama, Mobile, AL 36688.

Sarcomas, lymphomas and carcinomas in several species express a common 44 kDa glycoprotein antigen that is also expressed on mid-gestational fetal cells. We have termed this antigen oncofetal antigen (OFA). Cross-reactive anti-tumor immunity induced by immunization with tumor or fetal cells expressing this OFA can be adoptively transferred with cell populations containing T lymphocytes. We describe here the establishment and characterization of two types of T lymphocytes with distinct specificities that are induced by immunization with syngeneic tumor cells in two mouse strains. We find that 5 of 8 T cell clones derived from spleens of BALB/c mice immunized with MCA1315 fibrosarcoma cells are specific for an antigen shared by MCA1315 and MCA1321 tumor cells. The other 3 T cell clones from the BALB/c mice are specific for an antigen present on MCA1315, but not MCA1321 cells. Also, none of the clones are reactive with the OFA-negative BALB/c plasmacytoma MOPC-315. Only 25% of the T cell clones from spleens of RFM mice immunized to the RFM thymoma 5T proliferate in response to both 5T and 4T RFM thymomas. The remaining RFM clones respond only to 5T thymoma cells. The cross-reactive clones from both BALB/c and RFM mice specifically respond to purified, MCA1315 fibrosarcoma-derived 44 kDa OFA in the presence of syngeneic, irradiated antigen-presenting cells and IL-2. All of the clones from both mouse strains are CD3+, CD4+, alpha-beta TCR+ T cells that secrete gamma interferon upon antigen stimulation.

Some electrical characteristics of tomato seedlings : II. Effect of electrical stimulation. R. Lee, J. Reeves, and C. Olander. Department of Biology, Jacksonville State University, Jacksonville AL 36265.

Using a common variety of tomato, electrical activity was recorded from electrodes implanted in the stem after varying degrees of electrical stimulation. The types on responses their duration and amplitude will be described. Mean values of the amplitude and conduction velocities of these potentials in response to nondamaging electrical stimuli is reported. Data typically obtained will be presented. It was noted that the excitability level between similar plants on the same day and in the same plant on different days is variable and undergoes periodic changes.

Abstracts

DOLPHINS DEAD IN MOBILE BAY AT THE WRONG TIME OF YEAR. Gerald T. Regan, Department of Biology, Spring Hill College, Mobile, AL 36608. Sean P. O'Hare, Department of Biology, Univ. of South Alabama, Mobile, AL 36688.

The number of Atlantic bottlenose dolphins found dead in Alabama during 1993 was 46, the record for a year being 59 (1990), but 72 per cent were found in the last six months of the year, contrasting with a 35 per cent mean for 1988-1992 (range 27-42). All but one occurred in Mobile Bay or in nearby Mississippi Sound. Of those tested for the presence of dolphin distemper virus (Paramyxoviridae: Morbillivirus), 4 out of six were positive. The lengths of the dolphins that were positive ranged from 153 cm to 204 cm. Their sex ratio (m:f) was 1:1. The lengths for the whole year 1993 ranged from 95 to 266, and the 1993 sex ratio was 1:0.8. Neonates (length \leq 110 cm) made up 8.5 per cent of the 1993 total, neonate percentages in five previous years having fallen in the range 8.3-37.5. The 1993 percentage of dolphins with shark bites was 15, compared to the previous percentages: 1988:0; 1989:27.2; 1990:6.8; 1991:12.5; 1992:12.5. Correlates of the unseasonal mortality of 1993 were: 1) unusually high discharge from the Mississippi River after a 100-year flood; 2) an unusually cold interval in March; and 3) elevated fecal coliform counts off the east shore of Mobile Bay. Before the detection of distemper in Mobile Bay, the only other detection of it in the Gulf of Mexico was near Panama City, Florida, in June, 1993.

The authors collected tissue samples from freshly dead dolphins for histopathologic study by T. P. Lipscomb of the Armed Forces Institute of Pathology. Consultation reports resulting from such studies, together with information from other sources, suggested the following model. The virus is closely related to canine distemper virus but not to feline distemper. Dolphins contract the distemper virus in the form of an aerosol transported through the air from previously infected dolphins. Blood carries the virus throughout a dolphin's system. The distemper virus induces immunosuppression which predisposes a dolphin to infection by a fungus consistent with *Aspergillus*, the spores of which are presumably ubiquitous. The immediate cause of death is severe fungal pneumonia.

Some electrical characteristics of tomato seedlings : III. Effect of injury by burning. M. Stanfield, R. Lee, B. Edwards and C. Olander. Department of Biology, Jacksonville State University, Jacksonville AL 36265.

Using a common variety of tomato, electrical activity was recorded from electrodes implanted in the stem after varying degrees of injury by leaf burning. The types on responses their duration and amplitude will be described. Mean values of the amplitude and conduction velocities of these potentials in response to burning stimuli is reported. Data typically obtained will be presented. It was noted that the excitability level between similar plants on the same day and in the same plant on different days is variable and undergoes periodic changes.

Abstracts

CHEMISTRY

SYNTHESIS AND CHARACTERIZATION OF TITANIUM-CONTAINING COPOLYMERS FOR USE IN LASER FUSION EXPERIMENTS AT LLNL.

K. Branham, G. Gray, J. Mays, Dept. of Chemistry, Univ. of Ala. at Birmingham, Birmingham, AL 35294. R. Cook, G. Overturf, R. Sanner, Lawrence Livermore National Labortory, Livermore, CA 94550.

Soluble Ti-containing polymers are very useful diagnostic materials for studying nuclear fusion in laser fusion experiments. Incorporation of a Ti-containing copolymer in the inner layer (the mandrel) of the laser fusion target provides a spectroscopic probe for studying the fusion process through K-shell spectroscopy of the Ti atoms in the plasma. The extreme reactivity of most Ti compounds makes the development of reliable methods to prepare Ti-containing monomers and soluble Ti-containing polymers very difficult. Most polymeric systems containing Ti are catalyst/support materials or insoluble resins unsuitable for mandrel production. Soluble Ti-containing copolymers have been prepared by copolymerizing styrene with Ti-containing methacrylates. Laser fusion experiments using materials made by this method have been conducted at LLNL. We have also attempted to make Ti-containing copolymers by functionalizing copolymers prepared from styrene and some methacrylate derivatives with titanium reagents, but this method does not allow preparation of copolymers suitable for mandrel production. All soluble copolymers were characterized using ^1H NMR, C and H elemental analyses, and Size Exclusion Chromatography.

AN IMMUNOELECTRODE BASED ON A JEFFAMINE-MODIFIED GLASSY CARBON ELECTRODE. Sean Elliot, Deborah W. Manning, Stacy H. DuVall, Christine Jefnigan, Edward Williams, and Moore U. Asouzu, Troy State University, Troy, AL.

The surface of an electrochemically treated glassy carbon electrode was reacted with Jeffamine EDR-148 to provide the amine functionalities needed to immobilize biotinylated goat anti-rabbit IgG through reaction of biotin with neutravidin. The immunoelectrode was incubated with peroxidase-labeled and unlabeled rabbit anti-goat IgG. Cyclic voltammetry was then used to detect enzymatically-generated oxygen from the decomposition of hydrogen peroxide. The application of the immunoelectrode to other antigens that have specific antibodies developed in rabbit was demonstrated with the azidothymidine (AZT) molecule. Using the immobilized goat anti-rabbit antibody to anchor rabbit anti-AZT antibody and peroxidase as the enzyme label for AZT, we were able to measure AZT at a concentration of $4.68 \times 10^{-12} \text{ M}$. The immunoelectrode was used for more than 100 voltammograms during a 1-month period with little degradation.

Abstracts

ELECTROPHORESIS WITH ON-COLUMN TRANSIENT ISOTACHOPHORETIC PRECONCENTRATION. Chao-Cheng Wang and Stephen C. Beale, Dept. of Chemistry, University of Alabama, at Birmingham, Birmingham, AL 35294.

Capillary zone electrophoresis (CZE) is an efficient separation technique for analyzing ionic species based on differences in the electrophoretic mobilities. Typically in CZE, capillaries with inner diameter of 20-100 μ m are used and only 1-30nl of sample are injected. Although CZE provides an impressive mass detection limit, the detectable sample concentrations are limited to 10⁻⁶ M for UV detection. Isotachophoresis (ITP) is another electrophoretic separation technique carried out in a discontinuous electrolyte system formed by a high-mobility leading electrolyte and a low-mobility terminating electrolyte. During the ITP step, the concentration of all ionic components of the sample are rearranged according to the concentration and mobility of the leading electrolyte; the highly concentrated components are diluted and trace components concentrated. By proper selection of electrolyte system, on-line CZE with ITP preconcentration can provide a significant improvement in the detection limit for trace analysis.

Quantitative analysis of adenosine by CZE with on-column transient isotachophoretic preconcentration and LIF detection was studied. Borate buffer was used to convert the neutral ethenoadenosine derivative into the anionic borate complex. The borate system also functions as the terminating electrolyte for ITP and background electrolyte for CZE. Since isotachophoretic preconcentration allows injection volumes as large as 50% of the column volume, ITP-CZE concentration detection limits were two orders of magnitude lower than CZE. This approach provided quantitative analysis of adenosine at concentrations as low as 10⁻⁹ M.

SYNTHESIS AND CHARACTERIZATION OF Me₃Al AND Me₃Ga ADDUCTS OF SECONDARY AMINES. Rajiv Gala and Craig Lagronne, Birmingham Southern College, Birmingham, AL 35254; and Charles Watkins, Larry Krannich, and Steven Schauer, Univ. of AL at Birmingham, Birmingham, AL 35294.

The reactions of (Me₃Al)₂ and Me₃Ga with eleven (11) secondary amines (Me₂NH, Et₂NH, Prⁿ₂NH, Prⁱ₂NH, Buⁿ₂NH, Buⁱ₂NH, C₄H₈NH, C₅H₁₀NH, C₆H₁₂NH, CH₃NC₄H₈NH, and Bzl₂NH, where Bzl = PhCH₂-) have been carried out to give the respective group 13/15 adducts. These have been characterized using IR, NMR, EI-MS, and elemental analysis. NMR data confirm the formation of an adduct. A comparison of ¹³C α -C chemical shift data indicates that the magnitude of the chemical shift change upon adduct formation is similar for the analogous Al and Ga species. A strong correlation exists between the α -C ¹³C data of the free amine versus that of the adducted species, with the exception of C₄H₈NH and Prⁱ₂NH. In an attempt to correlate calculated and experimental IR data, molecular modeling of these adducts has been carried out using SPARTAN 3.0. AM1 and PM3 semi-empirical methods were employed. These results, as well as calculated geometries, will be discussed.

Abstracts

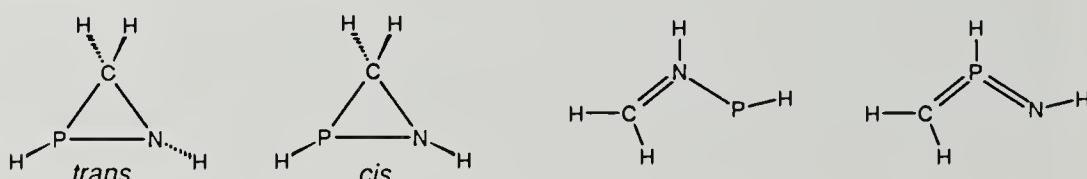
METHCATHINONE: SYNTHESIS, STEREOCHEMICAL ANALYSIS AND ANALYTICAL PROPERTIES. Jack DeRuiter¹, F. T Noggle², Lisa Hayes³, Allen Valaer¹ and C. Randall Clark¹, ¹Department of Pharmacal Sciences, School of Pharmacy, Auburn University, AL 36849, ²Alabama Department of Forensic Sciences, Wire Road, Auburn, Alabama 36831, ³Howard Hughes Future Life Science Scholar, Auburn University.

Methcathinone or "cat" is an amphetamine-type designer street drug that has been encountered recently in several northern states of the US. Like the amphetamines, methcathinone contains a chiral center and the central nervous stimulant activity resides primarily in the S-enantiomer. Methcathinone is prepared in clandestine labs from readily available starting materials such as the ephedrines and pseudoephedrines, and our studies have shown that each individual enantiomer of ephedrine and pseudoephedrine produces homochiral methcathinone via conservation of configuration. Thus 1R,2S-ephedrine and 1S,2S-pseudoephedrine yield S-methcathinone while 1S,2R-ephedrine and 1R,2R-pseudoephedrine produce R-methcathinone. The enantiomers of methcathinone were separated by gas chromatography as the diastereomeric amides following derivatization with S-(-)-N-(trifluoroacetyl)prolyl chloride (TPC). The GC-MS analysis of underivatized methcathinone shows a major chromatographic peak with a mass spectrum characteristic of the parent molecule as well as a secondary component which yields a molecular ion two mass units less than that of the major peak. Deuterium labeling experiments showed this minor component to arise through the thermal oxidation of the 2,3-carbon-carbon bond of the side chain to yield the 2,3-enamine. The presence of this minor component is significant since it may complicate the analysis of clandestine methcathinone samples.

STRUCTURES AND PROPERTIES OF AZAPHOSPHIRANE. Sara J. Strand and Koop Lammertsma, Dept. of Chemistry, University of Alabama at Birmingham, UAB Station, Birmingham 35294.

The synthetic and theoretical interest in three-membered ring structures is driven by their special reactivities that make them so versatile in many (bio)chemical reaction schemes. Here we report on *ab initio* molecular orbital studies on the new azaphosphirane system to support efforts for their synthesis in the laboratory.

The high level studies at the MP2/6-31G* theoretical level give credence to the possible synthesis of azaphosphiranes. The parent azaphosphirane is the global energy minimum of the various investigated isomeric structures and is significantly more stable than the ring-opened structures, the bis(ylene)phosphoranes. An analyses of the bonding features of thee compounds will be presented. We also report on the transitions for transformations and isomerizations at similarly high theoretical levels. Inversion barriers will be compared with those well established for trivalent nitrogen and phosphorus compounds.



Abstracts

SOLVATION OF THE PEROXYNITRITE ANION. Hui-Hsu Tsai and Tracy P. Hamilton, Dept. of Chemistry, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

The vibrational frequencies of peroxy nitrite (ONOO^-) are computed from first principles and compared with Raman spectra of ONOO^- in solution and in potassium nitrate crystals. Theory results for the *cis* isomer are in excellent agreement with experiment, except for the torsional band which is predicted to have a vibrational frequency at least 100 cm^{-1} below the observed peak. We have investigated various possibilities for this discrepancy. The ONOO^- in experiment experiences either solvent or crystal field effects, so the effect of solvent was calculated using the self-consistent reaction field method (which uses a spherical cavity in a dielectric medium). Since the torsion peak is strongly broadened by the solvent, we also performed quantum simulations of $\text{ONOO}^- \cdot \text{H}_2\text{O}$ and $\text{ONOO}^- \cdot 2\text{H}_2\text{O}$. Ion-molecule binding energies of 15 kcal/mol are predicted, but the solvent effect on the torsion frequency is minimal. Anharmonicity has also been taken into account using perturbation theory, with the result that the vibrational frequency is lower than the harmonic vibrational frequency (the usual case). Efforts are currently being made to determine if water molecules can hydrogen bond in a manner that will result in a ring structure (which will inhibit twisting and thereby increase the torsional potential barrier.) A more sophisticated solvent model in which a realistic cavity is used and the solvent is polarizable by the charge on the anion is also being considered.

Hydantoins with Conformationally Restricted Phenyl Rings: Correlations with Sodium Channel Binding. Milton L. Brown and Wayne J. Brouillette, Department of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294

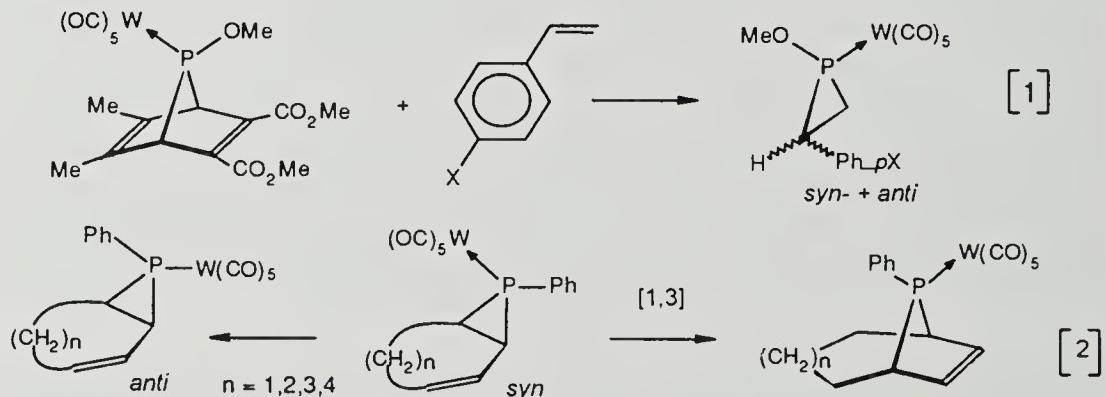
Diphenylhydantoin (DPH) binds to a site located in the neuronal voltage-sensitive sodium channel. Previous studies have suggested that the DPH binding site may require a specific aromatic ring orientation. We are interested in determining the optimum aromatic orientation for tight binding to this site, by measuring the *in vitro* allosteric inhibition of ^3H -batrachotoxinin A 20- α -benzoate for conformationally restricted 5-alkyl-5-phenylhydantoins. We have designed and synthesized spirocyclic hydantoins **1-4** which are estimated by Dreiding models to confine torsion angle C5, C6, C7, N1 to 70° (**1**), 10 to 110° (**2**), -20 to 140° (**3**) and -30 to 150° (**4**). Comparisons of the binding activities for these compounds revealed a preferred torsion angle range estimated to lie between -30 to 10° and 110 to 180° . We employed SYBYL, a molecular modeling program from Tripos Associates, St. Louis, MO., to design probes which can further refine the estimated torsion angle ranges and investigate potential receptor preferences for new phenyl ring orientations. All analogs were energy minimized with the Tripos force field and relative energies over conformational space were determined using search routines (GRID and SYSTEMATIC) within SYBYL. For each global minimum, a range of conformers within 2.0 kcal/mol were considered. In this manner we designed hydantoins **5-8**, which constrained the phenyl ring orientation to different regions of space than **1-4**.

Abstracts

REACTIVITY STUDIES OF PHOSPHINIDENE TUNGSTENPENTACARBONYL COMPLEXES. Bing Wang and Koop Lammertsma, Dept. of Chemistry, University of Alabama at Birmingham, UAB Station, Birmingham 35294.

Phosphinidenes [$R-P\sim W(CO)_5$] are carbene like species. The applications of this experimentally elusive intermediates have increased rapidly in the past decade. Our research concentrates on characterizing the reactivity of these new species. Here we report on the Hammett reaction constant of the methoxy derivative (Eq. 1) and on the rearrangement of various cyclodiene-phosphinidene adducts (Eq. 2).

The Hammett value will be compared with those of carbenes and other phosphinidenes. The transformation of the diene adducts will be discussed in terms of competing concerted and biradical pathways leading to [1,2]- and [1,4]-adducts.



RADON, DIOXIN, AGENT ORANGE, TRICRESYLPHOSPHATE, TRYPTOPHANE, ETC.
Carlton D. Whitt, 601 Schilling St. Athens, AL 35611-2931.

The 14 member uranium series of elements are very deadly poisons, not nuclear hazards. Radon, no hazard to man being less than 0.1 pCi per liter of air even in uranium mines. Justifying calculations presented. Dioxin no health hazard to man. Ten year test at plant site city in Italy on 400 people exposed to dioxin and similar group in same city unexposed showed exposed group better than unexposed group in every item in 10 yr. multi-range testing. TCP has been added in small amounts to gasoline and larger amounts to motor oil esp. for large planes and high speed jet planes. USAF leaving Libya, auctioned off motor oil, much was blended with some cheap cooking oil. Estimated 30,000 or more people were crippled for life and died soon; several merchants were executed from reports at that time. Alpha amino acids tyrosine and tryptophane: the gateways to alkaloid syntheses along with phenolic groups. Many people have very serious consequences from eating too much tryptophane recently. Brief comments on Agent Orange, absinth, metal organic compounds in medicine, super phosphate, tritium and hazards from our nuclear technology.

Abstracts

DETECTION ASPECTS OF CAPILLARY ISOELECTRIC FOCUSING. Sara Jane Sudmeier and Stephen C. Beale, Dept. of Chemistry, University of Alabama at Birmingham, Birmingham, AL 35294.

Capillary isoelectric focusing (CIEF) is a powerful separation technique used for the analysis of complex zwitterion samples based on isoelectric point (pi) differences. In a conventional CIEF system, the zwitterions to be separated are mixed with a solution of ampholytes having various pls. The mixture is added to a fused silica capillary tube, typically with an inner diameter of 50 to 200 μm , and an electric field is applied to establish a buffered pH gradient in the capillary. During the focusing process, zwitterions move to their equilibrium position along the gradient where pH = pi. The entire gradient is then mobilized past the UV detection window for detection of zwitterion bands. The technique is able to resolve zwitterions which differ in pi by less than 0.01 pH units.

Quantitative aspects of the CIEF separation process, such as precision and accuracy, were examined. Calibration data were collected for three proteins, myoglobin, trypsinogen and β -lactoglobulin B, with mobilization in the cathodic direction. Nonlinear calibration data suggests mobilization of focused zones results in irreproducibility in migration time and peak area. The mobilization process unavoidably causes distortion of focused zones and results in loss of resolution. Elimination of the mobilization step by further development and refinement of the instrumental design will be discussed.

USE OF A REGENERABLE IMMOBILIZED SECOND ANTIBODY TO DETERMINE AZIDOTHYMIDINE IN A FLOW SYSTEM. Stacy H. DuVall, Deborah W. Manning, J. Zhao, and Moore U. Asouzu.

A regenerable immobilized second-antibody reactor was used to measure azidothymidine (AZT) by competitive enzyme immunoassay in a flow system. The immobilized antibody was generated 4 times with little loss of immunospecificity. A residual enzymatic activity of about 7% of the total response was obtained with horseradish peroxidase as label. AZT was measured below the nanomolar level by allowing competition to proceed for about 2 min. A limit of detection of $6.57 \times 10^{-11} \pm 1.56 \times 10^{-11}$ M AZT was obtained when the concentration of AZT-peroxidase conjugate was 0.125 ng/mL. This system was used to determine azidothymidine in Retrovir capsule with good results. In replicate measurements, RSDs of 5.51% and 2.44%, n = 6, were obtained at 7.48×10^{-11} and 3.74×10^{-9} M AZT, respectively.

Abstracts

MONTE CARLO CHEMOMETRICS WITH SPREADSHEET PROGRAMS.
Jerry T. Gautney, Brian R. Hopkins, Michael B. Moeller and Brian D. Riley,
Department of Chemistry and Industrial Hygiene, University of North
Alabama, Florence, AL 35632.

Monte Carlo chemometrics involves stochastic modeling of experiments with the goals of optimizing experimental design, estimating the uncertainties in the results, and testing analytical methods for bias. The growing familiarity and widespread use of computer spreadsheets present an opportunity for more workers to employ this technique. Crucial to the process is a method for generating normally distributed random deviates. These can be conveniently provided by a Box-Muller transformation. If x_1 and x_2 are independent standard uniform deviates, then deviates z with standard Gaussian distribution are generated by: $z = (-2 \ln(x_1))^{.5} \cos(2\pi x_2)$. This paper examines two situations commonly encountered in analyzing data. The first situation involves the calibration of responses y to standards x and then using the line obtain from least squares analysis to estimate an x value for a sample with an observed y . The precision of the values obtained by assuming a $y = mx + b$ model is found generally inferior to values obtained if a $y = mx$ model is assumed. The second situation investigated in this work concerns the application of ordinary linear least squares (OLS) to data containing errors in the x values. The bias in the slope was found to be considerably less with the $y = mx$ model than with the $y = mx + b$ model.

SYNTHETIC APPROACHES TO THE DIASTEREOMERS OF 2-HYDROXY-3-(TRIMETHYLAMMONIUM)CYCLOHEXANECARBOXYLIC ACID, CHLORIDE.
Tracy L. Hutchison, Ashraf Saeed, and Wayne J. Brouillette, Department of Chemistry,
University of Alabama at Birmingham, Birmingham, AL 35294.

Carnitine, 3-hydroxy-4-(trimethylammonium)butyrate, is important in cellular metabolism as a donor and acceptor of acyl groups. In order to study carnitine's protein binding sites, rigid cyclohexyl carnitine analogs, 2-hydroxy-3-(trimethylammonium)cyclohexanecarboxylate, have been designed. Of the four possible diastereomers for these analogs, two were prepared as the major diastereomeric products resulting from the reduction of ethyl 5-chloro-3-nitrosalicylate. Two approaches were pursued for the preparation of a third diastereomer. The first involved Mitsunobu inversion of the β -hydroxy group. When this failed, a stereoselective synthesis was designed that incorporated regioselective ring opening of the epoxide of *trans*-methyl 2,3-epoxycyclohexanecarboxylate with NaN_3 . (Supported by NIH grant HL44668)

Abstracts

GC-MS ANALYSIS OF AMPHETAMINE PRODUCTS SYNTHESIZED FROM 1-PHENYL-2-NITROPROPENE. Jack DeRuiter¹, F. Taylor Noggle² and C. Randall Clark¹.

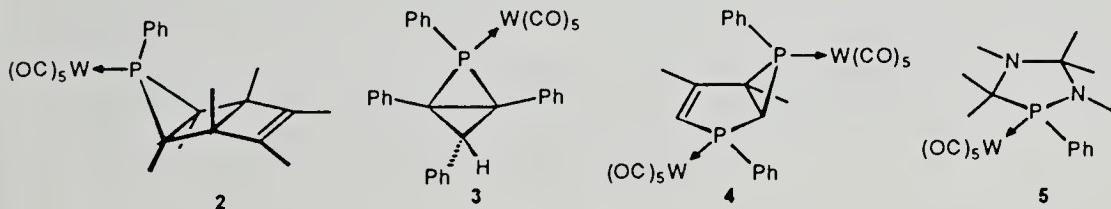
¹Department of Pharmacal Sciences, School of Pharmacy, Auburn University, Auburn, AL 36849 and ²Alabama Department of Forensic Sciences, Wire Road, Auburn, AL 36831

With tighter federal control of the precursor chemicals used for the manufacture of amphetamines, clandestine laboratory operators have begun to explore alternative methods for the synthesis of these drugs of abuse. One such method encountered in recent years involves the use of 1-phenyl-2-nitropropene (PNP) as a key precursor. PNP is prepared by treating benzaldehyde with butylamine and nitroethane. PNP may be reduced directly to amphetamine, or converted to another versatile intermediate, 1-phenyl-2-propanone (P-2-P), which may be aminated to a yield a number of related amphetamine-type compounds. In the present study, GC-MS analysis was used to investigate the conversion of PNP to amphetamine derivatives under a variety of reaction condition. These analyses revealed that amphetamine is produced as the major product when PNP is subjected to catalytic hydrogenation or hydride reduction with a large excess of lithium aluminum hydride (LAH). The conversion of PNP to P-2-P by partial reduction and hydrolysis was also studied and found to proceed cleanly and in good yield. Amination of P-2-P under Leuckart and reductive amination conditions provided amphetamine as the principle product. GC-MS analysis revealed that samples from these reactions also contain several by-products that are characteristic of these routes of synthesis.

PROGRESS IN PHOSPHINIDENE CHEMISTRY - NEW PHOSPHIRANES. Steffen Krill and Koop Lammertsma, Dept. of Chemistry, University of Alabama at Birmingham, UAB Station, Birmingham 35294.

Our studies aim to explore the carbene-like chemistry of phosphinidenes and to develop the synthetic potential of phosphiranes, which are their olefin addition products. In this pursuit we concentrate on the synthesis of strained systems, which are targeted for rearrangement and ring opening studies, and new phosphorus heterocycles. We report here on the syntheses and properties on several such new ring structures.

Trapping of the terminal phosphinidene complex $[\text{Ph}-\text{P}-\text{W}(\text{CO})_5]$ (1) with hexamethyl-Dewar benzene results in the exceptional tricyclic 2. Equally exciting is the synthesis of the highly strained bicyclopophosphabutane 3 of which the stereochemistry could be established by a single X-ray crystal structure determination. Trapping of complex 1 with a phosphole affords the dicomplexed bicyclic structure 4. Preliminary results will be presented on the ring opening of azaphosphiranes to generate 5, which are formal [2+1] cycloaddition products with imines.



Abstracts

REFRACTIVE INDEX MEASUREMENT OF SOME ORGANIC MATERIALS AND WATER*. Anthony Wilson and K. J. Chang, Department of Chemistry, Alabama A&M University, Normal, Alabama 35762. Benjamin G. Penn and Donald O. Frazier, NASA Marshall Space Flight Center, Alabama 35812.

Refractive index of a substance depends on the intensity of incident light and affects polarization, hence optical behavior of nonlinear optical materials. Thus, refractive indices of these materials should be determined for study and application of the materials in electrooptical devices.

In this work, refractive indices and film thicknesses of nonlinear optical organic materials with different substrates have been measured with He-Ne laser of 6328 Å by using a computer-controlled Gaertner ellipsometer. Also, the accuracy of the result obtained using our liquid sample cell is shown by comparing the refractive index of water measured in our lab with published literature values.

*This work has been supported by NASA Grant No. NAG8-173.

A MODEL FOR MULTI-ANTIGEN DETECTION. Deborah W. Manning, Stacy H. DuVall, Christine B. Jernigan, and Moore U. Asouzu, Troy State University, Troy, AL.

Enzymes have been used as labels in immunoassays to improve sensitivity and selectivity, and as substitutes to radioactive labels. In enzyme immunoassay, an unlabeled antigen competes with an enzyme-labeled antigen for available antibody binding sites. Then, bound enzyme activity is determined and related indirectly to the unlabeled antigen concentration. We will present a model for multi-antigen determination with an immunoelectrode to demonstrate the feasibility of measuring more than one antigen in a single assay in these systems. Our system uses alkaline phosphatase and horseradish peroxidase as model labels for IgG. The products of the enzymatic reactions involving these enzymes will be detected by Cyclic Voltammetry. The use of glucose oxidase as label will be proposed.

Abstracts

GEOLOGY

NEURAL-NETWORK PREDICTIONS OF PERMEABILITY FROM POROSITY.
Samuel Joe Rogers, Department of Geology, University of Alabama, Tuscaloosa, AL 35487-0338.

Predicting permeability in uncored wells is one of the central problems in reservoir characterization. Two main reasons are behind this difficulty: (1) it is not yet possible to quantitatively describe the heterogeneity of porous media and (2) the flow field is the solution of a set of partial differential equations which are difficult to compute. One solution to this problem is to use porosity measurements from well logs to predict the permeability values in uncored wells. Porosity logs are much less expensive to obtain than cores, and porosity often correlates with permeability. Unfortunately, the poor agreement between observed and predicted permeability values has plagued this approach. This study is concerned with providing a viable alternative to the prediction of permeability from porosity logs through the use of neural networks. This non-statistical method does not require sophisticated mathematics or large amounts of statistical data; neural networks learn from examples. The porosity and permeability values from cored wells provide examples to train the neural network so that it can predict the permeability values of neighboring wells using only their porosity well log values. Preliminary results using two cored wells from the Big Escambia field to train a neural network to predict the permeability from porosity values in a third well has provided better results than those achieved by traditional methods.

MICROBIAL REEFS IN THE SMACKOVER FORMATION OF ALABAMA. David C. Kopaska-Merkel, Geological Survey of Alabama, PO Box O, Tuscaloosa AL 35486-9780.

Small-scale bioherms and biostromes (reefs) in the Upper Jurassic Smackover Formation in Alabama are dominated by microbial stromatolites. Oncoids ("algal balls") overlie and underlie reefs and are incorporated within reefs. Oncoids and reefs probably represent microbial responses to differing energy regimes. Subspherical oncoids form under conditions of regular and frequent overturn, whereas flattened oncoids have been interpreted to form under conditions of infrequent overturn. Upwardly expanding oncoids appear to form when subspherical oncoids are grounded for extended periods, and are interpreted to record the incipient stages of reef formation. Grounded oncoids that avoid burial eventually become small microbial reefs or microreefs. This takes place by expansion of single oncoids, by coalescence of oncoids, by trapping of sediment particles among oncoids, and by microbial overgrowth of multiple oncoids and interstitial material. Small microreefs may coalesce to form larger ones, which consequently exhibit a complex internal fabric. The microreefs described here are centimeters thick and centimeters to tens of centimeters wide; some microbial boundstone bodies in the Smackover of Alabama are much larger. The demise of microreefs appears to involve burial by oncoidal pellet packstone/grainstone, with or without erosion of the top of the microreef. These features and relationships are illustrated with examples primarily from Uriah field in the Manila embayment.

Abstracts

GEOLOGIC INVESTIGATIONS IN THE FERN CAVE SYSTEM, JACKSON COUNTY, ALABAMA. Karen F. Rheams, Geological Survey of Alabama, Tuscaloosa, AL 35486

Geologic, hydrologic, and biologic studies by the Geological Survey of Alabama for the U.S. Fish and Wildlife Service to delineate the geographic extent of Alabama cave shrimp habitats in north Alabama have now been expanded to include Jackson County. The Fern Cave system, which is located on Nat Mountain just northwest of the town of Paint Rock, is comprised of three mutually joined caves: Fern Cave, New Fern Cave, and the Morgue. The entire system is under the protection of the U.S. Fish and Wildlife Service and access is through a restricted number of permits issued annually. Fern is an extremely complicated cave system composed of both a vertical and horizontal maze with over 12 separate levels that are interconnected by pits and canyons that appear to be strongly joint controlled. The Fern Cave system is the longest cave in Alabama with a surveyed length of more than 15 miles. With the uppermost entrance near the Bangor Limestone/Pennington Formation contact and the lowermost stream resurgence at the Tuscumbia Limestone/Monteagle Limestone contact, the cave system vertically traverses over 500 feet of stratigraphic section. Three major levels of cave passage have been recognized and indicate a complex formation history for the system. Speleothems and secondary calcite deposits are abundant throughout the Fern system making differentiation of the carbonate units difficult, but marine fossils are well preserved in some areas of the cave. A planned 5-year mapping program by the Fern Cave Project (FCP) has included studies by multidisciplined scientists with horizontal and vertical caving skills and experience. Recent mapping on Nat Mountain and within the upper and middle sections of Fern by the author for the FCP may provide insight into the geologic history of the area and the speleogenesis of this complex cave system.

TEACHING CHILDREN ABOUT THE EFFECTS OF HURRICANES AND TROPICAL STORMS. David C. Kopaska-Merkel and David J. Davies, Geological Survey of Alabama, PO Box O, Tuscaloosa AL 35486-9780.

As a part of the Geological Survey of Alabama's mission to provide the public with earth-science information, we are preparing a 35-mm educational slide set about hurricanes. The slide set focuses primarily on the effects of hurricanes and tropical storms and is aimed at children of school age. The slide set is accompanied by a brief report that describes hurricanes and summarizes the history of hurricane activity in Alabama. It also describes the effects of hurricanes (through the action of storm surge, high winds, waves and currents, rainfall, tornadoes, and secondary damage), and lists sources of advice about hurricane safety. The report also includes descriptions of each slide, and a ready-to-use classroom activity on hurricanes that K-12 teachers can use without help from an earth scientist. The 44 slides illustrate these same topics with specific examples. The slides compose a self-contained caption-driven presentation that can be used without reference to the report. The complete slide presentation takes about one-half hour. The report that accompanies the slide set could be read and understood by middle-school and high-school students. However, the slide presentation can be readily geared to children of almost any age. The classroom activity and student worksheet are most appropriate for elementary-school children. The hurricane slide set is one example of the kinds of educational materials that can be prepared on a wide variety of topics by earth scientists. We urge all earth scientists to take the time to translate their own expertise into fun and informative educational materials in the widest possible variety of formats.

Abstracts

FORESTRY, GEOGRAPHY, CONSERVATION, AND PLANNING

GROUND DRAWINGS IN THE PROVINCE OF NAZCA, PERU. Wilbur B. De Vall, Proxy Services, Ltd., Auburn, AL 36830.

Ground drawings are of two general types, rock alignments and gravel effigies. The former consist of rows of rocks in a wandering configuration. The latter are produced by raking aside the darker top soil to expose a paler subsoil. Both types are abstractions and/or representational of sacred projects rather than secular amusements. The formations were created much like drawing imaginary lines between stars in the sky to portray the well-known constellations. The Nazca Lines of southern Peru range from straight lines running for miles to geometric quadrangles, triangles, trapezoids, and spirals. Others are symbolic of giant creatures including birds, reptiles, whales, monkeys, and spiders. Because some of the figures resemble those used in decorating Nazca pottery, archeologists attribute the lines to the Nazcas, a coastal people whose culture rose, flourished, and declined between 100 B.C. and A.D. 700. Dr. Paul Kosok, the first scholar to study the markings after they were first discovered from the air in the late 1920's speculated that they may have constituted a giant astronomical calendar or almanac for farmers. Frau Maria Reiche, a German mathematician, photographed and charted las lineas for many years which resulted in her publication "Mystery on the Desert" in 1968. The markings lie along the Pan American highway and north of the town of Nazca ranging over an air-line distance of more than five miles. Lines run up and down slopes as well as along the flat desert floor. The National Geographic Society financed one of her studies and published an article in the May 1975 issue of the National Geographic titled "Mystery of the Ancient Nazca Lines" with photographs in color. Researcher Reiche presented the author of this paper with a copy of her 1976 book during a visit with her in 1987.

Ethnohistory and Archaeology: A Study of Upper Creek Settlement Patterns. Terry Lolley, Panamerican Consultants, Inc., P.O. Box 40930, Tuscaloosa, AL 35404.

A relatively large amount of ethnohistoric data is available on the Upper Creek Indians of Alabama, which can be combined with archaeological evidence to enhance our understanding of their lifeways. The aim of this paper is to provide an ethnohistoric model of Upper Creek settlement patterns, which can then be used in a settlement analysis through comparison with historical accounts and maps, modern topographic maps, and archaeological data. The model should manifest itself archaeologically in several ways: site locations, site organization, and inter-site patterning. The archaeological data is derived from surveys along the Coosa River by Dr. Vernon J. Knight of the University of Alabama.

Abstracts

DETERMINING THE VALUE AND OPTIMAL MARKET CONFIGURATION OF PCS LICENSING: A GEO-DEMOGRAPHIC MODEL. Jeffrey P. Richetto, Dept. of Geography, University of Alabama, Tuscaloosa, AL 35487. Mark D. Mullane, Dept. of Geography, University of Alabama, Tuscaloosa, AL 35487.

Increasingly, a fundamental prerequisite for the evolution of economic development at the regional, national and global level is the development of technologies which readily overcome the frictions of space and time. The two most important of such 'enabling technologies' include communications and transportation. Time and relative cost of transporting material, products and people have fallen dramatically as the result of technological innovations in transport media. However, such developments have depended on parallel improvements in communications technology.

Communication systems are the means by which information, in the form of ideas, data and images, is transmitted across the landscape. The emerging telecommunication technologies are the electronic highways of the informational age. Personal Communication Service, PCS, is a new form of wireless telecommunication that is technologically superior to conventional cellular. It operates in an all digital environment, requires less power, is independent of existing cable infrastructure, and has the capability of handling a greater capacity loading. Because of these and other characteristics cell sites are smaller and a greater number are required to create an integrated communication system. In turn, the number and geographic placement of cell sites help to determine the market value of a PCS license. It is within this context that this study will develop a geo-demographic model determining the value and optimal location of PCS licensing.

THE UNITED STATES SENATE, THE UNITED DAUGHTERS OF THE CONFEDERACY AND THE CONFEDERATE FLAG: THE POWER OF AN ICON. Gerald R. Webster, Dept. of Geography, Univ of Ala., Tuscaloosa, AL 35487. Roberta H. Webster, Dept. of History, Political Science and Geography, Samford Univ., Birmingham, AL 35229.

In July, 1993 the United States Senate voted against renewing the design patent for the insignia of the United Daughters of the Confederacy. Objections to the renewal centered on the appearance of the flag of the Confederate States of America (CSA) on the insignia, to some a symbol associated with slavery and racism. The central purpose of this paper is to examine the electoral geography of the Senate's votes on the patent renewal. This paper first considers the flag as an element of the South's iconography. Using statistical and cartographic means, it then examines the regional character of the Senate's votes on the patent renewal. It finds that Senate voting behavior was most impacted by each Senator's party affiliation, but that there were strong regional dimensions to the Senate's rejection of the patent renewal.

Abstracts

THE GHANA FERTILIZER POLICY SUPPORT SYSTEM: A PROTOTYPE FOR FUTURE SYSTEMS. Glenda Smallwood, Graduate Student, and T. Morris Jones, Professor, Department of Management and Marketing, University of North Alabama, Florence, AL 35632-0001.

The Ghana Fertilizer Policy Support System was developed at The International Fertilizer Development Center in Muscle Shoals, Alabama. The specific objective of this system is to provide a set of guidelines that may be used to establish a manageable fertilizer database that can then be used to develop and analyze fertilizer policies in Ghana. A broader objective of this system is to serve as a prototype for future comprehensive policy information systems which will be individually tailored to the specific needs of particular countries. Also, having useful and organized information is the key to designing effective government policies and actions.

The system was designed by a process approach. It has a very flexible structure which will make it be easily adaptable to the various needs of its users and operators. It presently contains eight modules which can be easily modified to support any future needs that emerge and have to be defined. Future work is also necessary to find, collect, and verify data to test the performance of the various modules. It should be emphasized that the development of any such comprehensive information system requires this type of process approach.

Geoarchaeological reconstruction of the recent fluvial history of Cane Creek, northern Alabama. Kelly D. Gregg, Dept of Geography and Archaeology, Jacksonville State University, AL 36265

As part of a long-term study of the fluvial geomorphology of the Coosa River system, a soil-geomorphic evaluation of the "Wright's Farm" site (1Ca18) was undertaken in conjunction with archaeological excavations. This site borders Cane Creek, a major tributary of the Coosa. In addition to traditional soil and stratigraphic description, archaeological evidence, historical records and oral interviews were used to help reconstruct recent fluvial history. The evidence suggests that this portion of Cane Creek has been very dynamic during the last 150 years, starting as a single-channel bedload stream, changing to a silt-choked, multiple-channeled braided system and now functioning as a rapidly incising single-channel carrying a large sediment load over a muddy bottom. These changes have apparently been the result of variation in patterns of land use.

Abstracts

TERRITORIALISM IN AMERICAN CITIES. Lewis A. Shumaker, Dept. of Geography, University of Alabama, Tuscaloosa, AL 35487. Jeffrey P. Richetto, Dept. of Geography University of Alabama, Tuscaloosa, AL 35487.

The subject of territorialism is of vital interest to geography, in general, and urban geography, in particular. At its most fundamental level territorialism refers to the 'behavior by which an organism characteristically lays claim to an area and defends it against members of its own species'. The underlying behavioral processes of territorialism manifest themselves in the urban environment both from an organizational and landscape perspective. On the one hand, individuals may organize themselves into representative groups (e.g., neighborhood organizations, the Chamber of Commerce, local civic clubs, etc.) in an effort to influence community planning decisions that may impact on their quality of life. On the other hand, the urban landscape is comprised of numerous tangible by-products of territorialism (e.g., symbolic marking of property, architectural and landscape design, graffiti, brick wall enclosures of neighborhood space, etc.) that impose visual and physical barriers limiting spatial mobility, constraining locational choices, and encouraging the creation and maintenance of defacto territories. It is within this context that this study investigates the nature and role of territorialism as it influences the evolution of the American urban landscape. To this end, the debate on territorialism from the field of anthropology is briefly reviewed and varying levels of territorial behavior exhibited by different ethnic groups, socio-economic classes, suburban versus inner city resident, and the role of territorialism in shaping the American city are explored.

FORREST AND GEOGRAPHY. Christopher D. Coker, Dept. of Geography, Univ. of N. Ala., Florence, AL 35630.

On June 10, 1864, Confederate general Nathan Forrest attained his greatest victory by defeating Union general Samuel Sturgis in the battle of Brice's Crossroads, near Baldwyn, in north Mississippi. Forrest systematically organized this battle by using the geography of the area to his advantage. Although his forces were half the size of the Union force, he believed the dense wooded area around the battle site would be an advantage to his guerilla style warfare. The torrential rains that had fallen the night before made travel to the battle site much more difficult for Sturgis' larger force than Forrest's smaller force. The hot, humid sun the morning of the battle suffocated the unadjusted northern soldiers and took a comparatively smaller toll on the southern troops. Forrest allowed Sturgis to cross the deep Tishomingo Creek before pinning him against this hazard. The only avenue of retreat across the Tishomingo was a narrow bridge, and when the Union forces were routed, the bridge became clogged with panic-stricken horses and men. Many Union soldiers were shot while trying to swim the creek. It is highly unlikely that Forrest could have won this battle without utilizing the geographic features such as the climate, the wooded area, and the Tishomingo Creek. This is only one of many instances where Forrest maximized the geography of an area to win a battle.

Abstracts

ULTRAMAFIC ROCKS OF THE ALABAMA PIEDMONT. Jonathan W. Mies, Department of Physics, Geology, and Astronomy, University of Tennessee at Chattanooga, Chattanooga, TN 37403. Lewis S. Dean, Geological Survey of Alabama, 420 Hackberry Ln., Tuscaloosa, AL 35486.

Ultramafic rocks are a unique suite of igneous rocks associated with mobilized orogenic belts around the world. In the Appalachian orogen, the southernmost exposure of ultramafic rocks is in the Alabama Piedmont. A summary overview of all identified ultramafic rocks in terms of mineralogy, chemistry, and structural relations has been made to evaluate the probable origin and tectonic history of these bodies and to provide a basis for future geologic investigation and mineral resource assessment. In the northern Alabama Piedmont, ultramafic rocks are restricted to and are a minor constituent of the eastern Blue Ridge belt. Several small, concordant ultramafic bodies occur among units of the Ashland supergroup in close association with interdigitated amphibolite. In Cleburne and Clay Counties, ultramafic bodies (Needmore, Red Hill, Poe Bridge Mountain) are composed of hornblendite with relic olivine and orthopyroxene; minor constituents include Mg-chlorite, Cr-pleonaste, ilmenite, magnetite, and serpentine-group minerals. Metapyroxenite at the interior of each body is coarse grained, whereas that at the peripheral margins is finer grained and schistose. Schistosity in ultramafic tectonite is approximately parallel to schistosity and compositional layering in adjacent country rock, indicating co-evolution of rock fabric. The limited development of tectonite fabric in ultramafic bodies is consistent with their having been more competent than country rock during deformation (emplacement?). In the Inner Piedmont of Alabama, ultramafic rocks are associated with mafic rocks which are a major constituent of the Dadeville complex. Eighteen ultramafic bodies and clusters of bodies (complexes) are presently delineated in the Inner Piedmont of Tallapoosa and Chambers Counties. These ultramafic rocks were investigated as early as the 1850's, and several sites exhibit prehistoric use by Native American Indians who recognized the value of this material for manufacture of bowls and other utensils. Inner Piedmont ultramafic rocks are typically dike- or sill-like bodies of metapyroxenite (with associated metagabbro and metanorite) enveloped by amphibolite. In the Dudleyville area of Tallapoosa County, ultramafic rocks (and associated alteration products of talc-anthophyllite) contain the only identified megascopic cumulate textures in layered chromite pods. Chromite is also a common to abundant detrital mineral in streams draining the Dudleyville area.

HOUSING VALUE CHANGE AND ECONOMIC DEVELOPMENT IN TUSCALOOSA COUNTY, ALABAMA, 1980 - 1990. Jeffrey P. Richetto, Dept. of Geography, University of Alabama, Tuscaloosa, AL 35487. Cynthia L. Sutherland, Dept. of Geography, University of Alabama, Tuscaloosa, AL 35487.

Important to the maintenance and economic growth of a community is the continued location and development of a balanced mix of public/private projects. While there exists many types of economic development including retail/commercial, office, industrial and public works, it appears that the impact accompanying these developments varies in magnitude, type and areal extent. As a result, mapping and analyzing such spatial change across a community's landscape represent key components for a community planner in monitoring and coordinating development activities that will increasingly improve the residential and economic environments. In particular, by exploring the relationship between economic development and spatial/temporal changes in housing values may assist in identifying areas in a community of economic growth and economic decline. It is within this context that this study examines the type, magnitude and geographic extent of impacts on housing values caused by different types of economic development. Specifically, the study employs a cartographic analysis to determine trends in the spatial variation of housing values for Tuscaloosa County, Alabama between 1980 and 1990. Data collected at the census tract and block levels form the basis for the analysis.

Abstracts

GEOLOGIC APPLICATIONS OF REMOTE SENSING. Deborah L. Wilson, Dept. of Geography, Univ. of N. Ala., Florence, AL 35632-0001.

The use of remotely sensed data is important in geologic applications because much of the information is not directly accessible from the surface of the earth. Many different systems can be used to meet the specific needs, with most applications involving the use of several different data sources. This study examined the different types of remotely sensed data available, and how they met the needs of the various geologic applications. The information was then examined further to recommend a sensor that could be used for a broad spectrum of applications. The cost, resolution, and availability of the data, as well as the requirements of specific applications, were examined. Global positioning systems, seismic data and other types of sensing systems are important geologic tools but are not applicable to use with broad spectrum applications. Aerial photography represented the widest range of uses for the lowest cost, while still retaining very good resolution. This type of imagery does have its drawbacks in that it is not suitable for applications requiring multiple bands of differing spectral reflectances. For these geologic applications the use of satellite imagery is recommended. As technology changes, sensors will be developed for use in geologic applications that not only have the capabilities of multispectral satellite images but also the resolution and lower costs of aerial photography.

HERITAGE TOURISM IN THE "BLACK BELT" OF WEST CENTRAL ALABAMA. Tom L. Martinson, Department of Geography, Auburn University, Auburn, AL 36849.

The "black belt" of west central Alabama (Butler, Perry, Lowndes, Wilcox, and Dallas counties) has many attractions appropriate for heritage tourism, including the remains of the antebellum plantation economy, especially its mansions, and ethnic tourism sites, especially the monuments and memorials to the civil rights movement. Development of both these elements of the landscape will contribute to the growth of this distinctive region.

Abstracts

INTEGRATING GEOGRAPHY AND HISTORY IN THE SOCIAL STUDIES CURRICULUM.
Andy R. Bradford, Dept. of Geography, University of North Alabama,
Florence, AL 35632-0001.

Since the 1992 Alabama Social Studies Course of Study mandates teaching a history/geography framework, it is essential that courses be developed for preservice teachers so they can be shown how these two subjects can be integrated into the public school curriculum. This presentation, a model syllabus, represents one approach to a design of an integrated course that captures the essence of the history and geography content areas. Organized around themes and ideas which have influenced the world and its inhabitants economically, physically, politically, and socially, the course provides for analysis of the context, consequences, and connections of such ideas in both the temporal and spatial dimensions while seeking to develop a sense of perspective whereby events are interpreted locally and globally in terms of pattern and scale. Vital to the course is an identification and examination of characteristics that make a territory important, thereby demonstrating the concepts of absolute and relative location and place. By tracking the movement of people about the earth, preservice teachers will be assisted in understanding concepts such as overpopulation and cultural diffusion and how they are associated with circumstances including job opportunity, climate, and transportation capabilities.

THE USE OF AERIAL PHOTOGRAPHY TO DETECT POLLUTION LEVELS IN THE CAHABA RIVER BASIN. Mark Brewer, Cresha Cason, and Christopher Newton, Department of History, Political Science, Geography, Samford University, Birmingham, AL 35229.

Because of its importance to the Birmingham area, the Cahaba River became the subject for our analysis on various freshwater pollution levels as determined through remote sensing and field investigation. The project centered on three study areas that we believed would reflect different pollution levels in the river. Study area 1 is located near Riverchase and has been subject to heavy development over the past 12 years. Study area 2 is located in Leeds, a location that has also experienced much development in the last few years. Study area 3 is in Lake Purdy, one of the main natural recreational sites in Alabama. Our original hypothesis was that site 1 would be moderately polluted, site 2 to be heavily polluted, and site 3 virtually pollution free. We utilized aerial photographs and field investigation to test this theory.

Abstracts

MONEY VS. CONSCIENCE: THE DISAPPEARANCE OF AMERICAN OLD-GROWTH FORESTS.
Angelia L. Mance, Dept. of Geography, Univ. of N. Ala., Florence, AL
35632-0001.

Old-growth forests are virgin forests containing massive trees that are often hundreds of years old. Examples include forests of Douglas fir, western hemlock, and giant sequoia in the western United States and loblolly pine in the Southeast. These forests contain a much greater diversity of plant and animal life than secondary forests. Since 1620, an estimated 95 to 97 percent of these old-growth forests that once covered much of America's lower 48 states have been cleared away. The few remaining fragments that have not been cut down are those in public lands in the northwestern United States. Approximately 80 percent of the area of these remaining old-growth forests is slated for logging. This has led to an intense struggle over the fate of these irreplaceable ecosystems that are nonrenewable on a human time scale. Politically powerful officials of timber companies want to cut these trees for short term profit and replace them with fast growing trees that can be harvested every 45 to 65 years, instead of the at least 200 years required for the growth of a secondary forest after a virgin forest has been cut. Environmentalists believe that most of these diverse ecosystems should not be destroyed to serve the interests of these corporations. The destruction of these American old-growth forests truly is a matter of money vs. conscience.

G.P.S.: ITS USES AND APPLICATIONS. Jason Shaneyfelt, Dept. of Geography, Univ. of N. Ala., Florence, AL 35632-0001.

Global Positioning System (G.P.S.) was merely a new idea in 1985. Since that time, G.P.S. has developed and become a great asset to many different fields of work, especially in the field of geography. G.P.S. receivers have the ability to communicate with special satellites, which through the process of triangulation, can calculate within 30m the longitude, latitude, and altitude of any given area. This ability has great potential for locational applications during wartime which was exhibited during Operation Desert Storm.

Abstracts

PHYSICS AND MATHEMATICS

A NON-DESTRUCTIVE LIPP METHOD FOR STUDYING THE CHARGE DISTRIBUTION IN DIELECTRICS. W. Wayne Yeh, Dept. of Physics, Tuskegee University, AL 36088.

In the past few years, several non-destructive methods have been developed to directly measure the electric field (or space charge) distribution of dielectrics. In this study, one of the methods, Laser-Induced Pressure-Pulse (LIPP) method, is employed to measure the electric field distribution inside a Mylar sample. The idea of LIPP method is to introduce a pressure wave generated by the impact of a laser pulse on a target layer to the sample surface. The sample is compressed as the pressure wave travels through. In the compressed region, first, the space charges that follow the atomic lattice are displaced. Second, the dielectric constant changes due to the variation of local space charge. These effects produce induced charges on the electrodes. Depending upon the load impedance, open-circuit or short-circuit, the induced charges produce a voltage difference across the electrodes or a current flow in the external circuit. The time dependent voltage or current contains information on the spatial distribution of charge of the sample prior to the compression.

A direct measurement of the electric field distribution inside a Mylar sample has been performed by using the Laser-Induced Pressure-Pulse (LIPP) method. The results showed that, first, the magnitude of the electric field (or space charge) increased with increasing applied voltage. Furthermore, the direction of the electric field inside the sample (or the polarity of the space charges near the sample surfaces) reversed as the applied voltage was removed.

THE CHAUVENET CRITERION FOR EXPERIMENTAL DATA: A CRITIQUE.
Larry D. Parks, Mathematics and Physics, University of Mobile, Mobile,
AL 36663-0220.

This paper presents an analysis and statistical critique of the chauvenet criterion: a "standard" acceptance/rejection technique for experimental data.

The collection of experimental data for analysis, prediction and mathematical modeling requires an acceptance/rejection criterion due to the stochastic nature of data collection. The chauvenet criterion is derived and then compared with other criterion (eg. least squares, min. - max. etc.) for data acceptance/rejection. Lastly, a simple criterion is derived as a competitor for the chauvenet criterion.

Abstracts

THE FRAGMENTATION OF SOLWIND -- A U.S. ASAT EXPERIMENT IN SPACE.

A. Tan, Dept. of Physics, Alabama A&M Univ., Normal, AL 35762.

F. Allahdadi and S. Maethner, Phillips Lab., Kirtland AFB, NM 87117.*

The planned fragmentation of Solwind P78-1 satellite is perhaps the first and only U.S. ASAT experiment against a live target in space. This event is analyzed from the USAF and NORAD radar data on the fragments obtained following the experiment. The three orthogonal components (radial, down-range and cross-range) of the velocity perturbations received by the fragments were calculated from the orbital elements of the target and those of the fragments, from which the angular distribution of the fragments were obtained. Scatter plots of the velocity components reveal groups of 3 or 4 fragments having similar velocity changes, which indicates that these fragments probably originated from the same parts of Solwind. The angular distribution of the fragments show a primary and a secondary area of concentration of the fragments, the latter possibly indicating the entry point of the ASAT into its target. A study of the radar cross-section data indicates that both Solwind and the ASAT underwent thorough fragmentations during the encounter. The velocity of the ASAT at the moment of impact and the angle of encounter are estimated by different procedures. The possibility that 3 fragments ejected with the greatest velocity perturbations into the highest energy orbits were parts of the ASAT which ricocheted off Solwind is discussed.

*This study was supported by AFOSR Contract F49620-90-C-09076 through the Subcontract 93-7 from Research & Development Laboratories.

DYNAMICS OF A RIGID BODY IN THE GRAVITATIONAL FIELD OF A ROTATING MASS. Govind K. Menon and J.H. Young. Univ. Al. at B'ham., Birmingham, AL 35294.

Induced rotations of extended rigid bodies by Newtonian gravitational gradients have long been understood. The post-Newtonian gravitational field, resulting from weak field approximations of the Einstein field equations expressed in terms of three dimensional vectors, offers certain gravitational characteristics which have no Newtonian counterpart. Features of Einsteinian gravity are easily accessible in this development, as the gravitational field equations are presented in a coupled system which is virtually identical to Maxwell's equations. A rotating spherical mass, for example, will produce a dipole-like field component in addition to the dominant radial component much like a charged, rotating sphere would produce a magnetic dipolar field in addition to a radial electric field. Motions of a rigid body in the field of a rotating mass will be discussed and illustrated by a dumbbell. Special attention will be paid to the non-Newtonian effects resulting from the rotation of the central mass.

Abstracts

A DEGENERATE FOUR-WAVE MIXING STUDY OF THIRD-ORDER OPTICAL NONLINEARITY OF TRANSITION METAL CONTAINING ORGANIC COMPLEXES. Tianyi Zhai, Chris Lawson and Michael Lewis, Dept. of Physics, and Gary Gray, Dept. of Chemistry, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

The third-order nonlinear optical property for samples of molybdenum (Mo), palladium (Pd), platinum (Pt), rhodium (Rh), and tungsten (W) complexes has been measured by the degenerate four-wave mixing technique. Most of the complexes have a molecular structure of $C \equiv O$ and phosphine ligands coordinated on the metal atom. Analysis indicates that the nonlinear optical mechanisms that lead to these γ values are nonresonant. The results show that the electron donor/acceptor ability of the substituents on phosphine ligands does not affect the mono(phosphine) Mo complex's third-order nonlinear optical response at all, while its effect on the bis(phosphine) complex is limited. The major factor that dramatically enhances second-order molecular hyperpolarizability is the π -electron structure of the substituents on the phosphine ligands. It has been found that the larger the number of the substituents of a π -electron structure on phosphine ligands, the larger the observed third-order nonlinearity. For molybdenum complexes, the magnitude of the second-order molecular hyperpolarizability increases approximately as the 5th power of the number of substituents having a π -electron structure. It is also observed that for the complexes with the same type phosphine ligand, the cis-type complexes yield a larger γ value than that of the complexes with the trans-type coordination geometry. The type of metal does affect the measured second-order molecular hyperpolarizability, though the effect is not as drastic as that of the π -electron structure substituents on ligands.

INTERACTIVE DIGITIZED VIDEO USED IN TEACHING PHYSICS. Clarence J. Angelette, Dept. of Physical Sciences and Engineering, Jacksonville State University, Jacksonville, AL 36265.

Images from analog video sources can be digitized and these images or images from digitized video sources can be captured by a Macintosh computer as a QuickTime movie. Single frame video or movie clips (with audio) can be edited into QuickTime movies using Adobe Premiere software. Using X-Commands, a HyperCard stack can control the accessing of single frame video or play the movie clip as QuickTime movies and incorporate these in an instructional program. The playback speed can vary from one frame per second to 30 frames per second. Hypercard stacks can also control and incorporate single frame video or movie clips from external sources such as video disks into the instructional program. Each digitized frame can be set up for measurement that includes coordinates, length, time, angles and light intensities among other parameters. Using National Institute of Health software, NIH Image measurements can be stored and transmitted to a spreadsheet for analysis. All this at the touch of a button on a HyperCard stack card.

Abstracts

OBLIQUE HYPERVELOCITY IMPACT AND RICOCHET PHENOMENON IN SPACE.
A. Tan, Dept. of Physics, Alabama A&M University, Normal, AL 35762.
F. Allahdadi and S. Maethner, Phillips Lab., Kirtland AFB, NM 87117.*

The analysis of Solwind P78-1 satellite fragmentation data reveals the existence of three fragments which were thrown out with extremely large velocity boosts in the forward direction into the highest energy orbits among all fragments. Whether or not these represented ricochet fragments resulting from oblique hypervelocity impact between Solwind and the ASAT is discussed. The velocities of Solwind, the ASAT and the fragments are calculated from their respective orbital or suborbital trajectories. The angles of encounter, impact, incidence and ricochet are defined and determined. The possible area of impact and the probability density of impact are estimated. The observed angle between the ASAT and the ricochet fragments suggests that incidence near 45° was possible. The significantly higher ricochet speeds compared with the relative speed between the target and the projectile are not inconsistent with computational results obtained from MAGI Smoothed Particle Hydrodynamic Codes. The possibility that the three fragments were actually parts of the ASAT which ricocheted off Solwind could not be ruled out. If true, this would be the first documented case of hypervelocity impact and ricochet phenomenon recorded in space.

*This study was supported by AFOSR Contract F49620-90-C-09076 through the Subcontract 93-7 from Research & Development Laboratories.

INFLUENCE OF SUBSTITUENTS ON HYPERPOLARIZABILITY OF SUBSTITUTED BENZYLIDINE-ANILS*. K. Bhat, K.J. Chang, M.D. Aggarwal, W.S. Wang Dept. of Physics, Alabama A&M University, Normal, AL 35762. Mohan Sanghadasa and T.A. Barr Jr., Dept of Physics, Univ. of Ala. Huntsville, Huntsville, N.B. Laxmeshwar, Institute of Science, Bombay, India, Benjamin G. Penn and Donald O. Frazier NASA/Marshall Space Flight Center, AL 35812.

Substituted benzylidene-aniline derivatives with different substituents at para position to the imine linkage on the aniline moiety indicate that hyperpolarizability increases with the type of acceptor group substituent. The sp^3 hybridization connecting the hetero atoms in the bridge -CH=N- linkage gives a tetrahedral geometry. This does not allow efficient overlap between the lone pair containing donor orbitals and the π orbitals of the benzene ring. Introduction of acceptor groups is found to be more effective with -CN, -NO₂, -CONH₂ groups in increasing order. Results from EFISH measurements verify this observation. Amide substituent is found to be comparable with nitro substituent in asymmetric polarizability. The proper hybridization and longer extension of the benzene conjugation may be the reason for the effectiveness of the acceptor group.

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Abstracts

POST-NEWTONIAN GRAVITY: CHARACTERISTICS AND CONSEQUENCES. J.H. Young, Dept. of Physics, Univ. Al. at B'ham, Birmingham, AL 35294.

The similarity of the Poisson equations separately obeyed by the static electrical and gravitational potentials led Heaviside (1893) to speculate on further analogies between the two fields. In particular, if Newtonian gravity were made time-dependent, perhaps an additional field characteristic would emerge analogous to the creation of a magnetic field by a time-varying electric field. The emergence of Einsteinian gravity some twenty five years later brought on the realization of numerous non-Newtonian gravitational effects, although the mathematical complexity of Einsteinian gravity made the unmasking of such effects difficult. Recent efforts have been made [e.g., Braginsky, Caves, and Thorne, *Phys. Rev.*, 15(8), 2047 (1977) to elucidate the nature of the Einstein field equations by representing them in three dimensional form in weak field cases. The results have been to provide a system of equations strikingly similar to Maxwell's equations, and virtually identical to those proposed by Heaviside. A discussion of that system will be presented along with a description of the dynamics of particles subjected to particular examples of such fields.

USING THE CASIO 7700 IN TEACHING PRECALCULUS. Dr. Judy Massey, School of Science and Mathematics, Livingston University, Livingston, AL 35470.

Livingston University has required student use of a graphing calculator in College Algebra, Pre-Calculus/Trigonometry, and higher mathematics courses for about three years. We now have overhead versions of the Casio 7000, the Casio 7700 and the TI-81. Beginning students' visualization skills are weak. Students are fascinated with calculators and are excited by the magic they produce from the first day of class. This produces a positive atmosphere in the classroom and keeps students motivated. Students are eager to experiment with their machines. I have successfully written and used several programs to help teach translations and other changes in polynomial functions, exponential and logarithmic functions, trigonometric functions, polar graphing and parametric graphing. Several graphs may be superimposed on the screen, allowing comparisons to be made.

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INTERACTIVE DIGITIZED VIDEO USED IN TEACHING PHYSICS. Clarence J. Angelette, Dept. of Physical Sciences and Engineering, Jacksonville State University, Jacksonville, AL 36265.

Images from analog video sources can be digitized and these images or images from digitized video sources can be captured by a Macintosh computer as a QuickTime movie. Single frame video or movie clips (with audio) can be edited into QuickTime movies using Adobe Premiere software. Using X-Commands, a HyperCard stack can control the accessing of single frame video or play the movie clip as QuickTime movies and incorporate these in an instructional program. The playback speed can vary from one frame per second to 30 frames per second. Hypercard stacks can also control and incorporate single frame video or movie clips from external sources such as video disks into the instructional program. Each digitized frame can be set up for measurement that includes coordinates, length, time, angles and light intensities among other parameters. Using National Institute of Health software, NIH Image measurements can be stored and transmitted to a spreadsheet for analysis. All this at the touch of a button on a HyperCard stack card.

QUANTIZATION OF LATTICE VIBRATIONS.* S.R. Roy and P.C. Sharma, Department of Physics, Tuskegee University, Tuskegee, Alabama 36088.

The computation of the possible mode of vibration of a real three dimensional solid is extremely difficult but the essential ideas for understanding the general properties of normal modes has been derived by considering a linear chain of atoms. We consider a single linear chain consisting of N identical atoms of mass M, held together by harmonic force acting only between adjacent atoms and constrained to move along the length of the chain. Here it has been shown that the vibrational energy of a lattice is quantized and yeilds an infinite conductivity.

*This research work was supported by the Strategic Defense Initiative by it's Office of Innovative Science and Technology through contract with the NSWC and DNA.

MATHEMATICAL INDUCTION AND THE TOWERS OF HANOI. Gene G. Garza, Dept. Of Mathematics, Univ. Of Montevallo, Montevallo, AL 35115.

Mathematical Induction is a difficult concept when first encountered by freshmen in a pre-calculus course. To make it more understandable (and possibly even enjoyable) a "visual" example may be used. The Towers of Hanoi puzzle can serve as an excellent resource for this purpose. Assuming $P(k-1)$ (i.e., $k-1$ disks can be moved in 2^{k-1} moves) and using that to show, physically, the minimum number of moves for k disks allows for an association which should add significantly to understanding and later recall of this important concept.

Abstracts

INDUSTRY AND ECONOMICS

THE BABY-BOOMER SANDWICH. James G. Alexander, Department of Economics and Finance, and Marsha D. Griffin, Department of Marketing, Alabama A&M University, Normal, AL 35762.

No generation in American history has had a larger--or more self-conscious--impact on society than the "baby boomers" born in the aftermath of World War II. The high birth rates from 1946-1964 added 76 million youth to a newly--and also self-consciously--emergent dominant world power. America's (belated) acceptance of the mantle of world leadership coincided with a period of unprecedented prosperity, creating an ideal incubator for the birth of a generation whose sights were set on possibilities rather than limitations. This, of course, vastly differentiated the baby-boomers from their elders who had experienced the constraints imposed by a decade and a half of depression and war. Now this first post-WW II generation is moving into the nation's leadership spotlight in government, corporations, schools, and other institutions. As it does so, there are doubts about its capacity and its outlook. The group which was supposed to be not only the largest, but also the best educated, least inhibited, most creative--in short, the best and the brightest--appears less focused, more fragmented, than expected. How it responds is a matter of great national and international importance, especially inasmuch as this generation is assuming national leadership at a comparatively early age. The baby-boom generation, leaders and others, has found itself sandwiched in a variety of ways. The now commonly recognized sandwich phenomenon is demographic: not only caught between old and young, but also caught there in circumstances calling for substantial simultaneous material support in both intergenerational directions while facing uncertainty concerning its own old-age security. Beyond this demographic aspect, however, the sandwich also has economic, cultural, and philosophical dimensions. Competition for places on the upward economic escalator has intensified, socio-cultural role definitions have been modified, and the very existence of a "public interest" has been called into question. How these issues are resolved will prove to be critically important not only for the baby-boomers, but for the nation as well.

Market Segmentation Via Factor Analysis. Keith Absher, Gerald Crawford, and Claude A. Hale, School of Business, Department of Marketing, Management, and Computer Information Systems, University of North Alabama, Florence, AL 35632.

This research identifies market segments based on student's classification of influence variables in the selection of a college or university. The study has identified, through the use of FACTOR ANALYSIS, nine principal factors which meet pre-established statistical criteria. The factors were broken down according to size and were given descriptive names. There were two major segments that accounted for fifty-five percent of all students ("warm friendlies" and the "local classroomers"). The other 45 percent are divided among seven minor segments ("socialities," "advice seekers I and II," "recruits I and II," "money matters" and "extras oriented".)

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ACADEMIC INSTRUCTOR BURNOUT AT THE UNITED STATES AIR FORCE SENIOR NONCOMMISSIONED OFFICERS ACADEMY. Richard R. Robold, Director, Student Operations, USAF Senior NCO Academy, 550 McDonald Street, Maxwell Air Force Base, Gunter Annex, AL 36114-3107.

Many researchers conclude that education is a profession marked by high levels of stress or the experience of "burnout." This study examines the burnout experienced by the academic instructors (AI) assigned to the USAF Senior NCO Academy and includes burnout research and data gathered by the author in an original study in 1991 and a follow-up study in 1993. In both studies, the problem was to identify contributors to AI burnout and make recommendations. The purpose of the 1991 study was to design, implement, and evaluate a method of relieving the instructor burnout. In that study, the hypothesis was that a reduction in instructor/student contact hours would reduce burnout symptoms. To achieve this reduction, a change in the utilization of instructors was accomplished through the use of a roving instructor to teach a module of instruction which resulted in an 8 to 16 percent reduction in contact hours. Measurement of success for the 1991 intervention involved three methods: a burnout survey, participant critiques, and student academic performance. The intervention was well received and achieved a reduction in the measured burnout indicators; however, this reduction was not statistically significant (.05). The 1993 follow-up study updated the literature review and administered the burnout survey to a new population of AIs. The 1993 results showed a mean tedium score rise of .35, a median rise of .50, and a mode rise of 1.68. The follow-up study did not support the 1991 results due to uncontrollable intervening variables which produced internal validity flaws.

ECONOMIC DIVERSIFICATION AND FOREST RESOURCE DEPENDENCE: A LITERATURE REVIEW. William K. McAllister, Department of Community Planning and Urban Studies and Eric N. Rahimian, Department of Economics and Finance, Alabama A & M University, Huntsville, AL 35762.

This review of literature focuses on forest dependent communities and their successes in local economic diversification. Interest in this subject is strong because of several factors including the impact of the Endangered Species Act on all forest lands, the application of ecosystem management principles to the U.S. National Forest System, and the technological innovations in timber harvesting and processing. Each factor has considerable impact on the resource dependent local workforce and, in turn, on the economies of the surrounding areas. Existing research comes primarily from sociology in the areas of community leadership and self-development and from economics in development and welfare dependency. Welfare impacts on a community are influenced by exogenous factors such as changes in world prices of forest products and changes in timber supply. Unlike many examples of decline, losses of jobs in the relatively higher paying timber industry can be particularly traumatic. Literature on community economic diversification does not sufficiently address forest dependency and its relationship to the evolving purposes of the 191 million acre National Forest System imbedded in ecosystem management. Literature suggests that diversification of the economy of a forest dependent community reduces dependence on forest extraction activities. New policy directions encourage tourism, recreation, cooperatives, locally controlled industrial development and incubator or small business enterprises rather than a single dominant employer.

Abstracts

A STUDY OF CURRENT RECORDS MANAGEMENT PROCEDURES IN BUSINESS AND INDUSTRY, 1992-1993. Margie S. Crocker, School of Business, University of North Alabama, Florence, AL 35632-0001.

Data for this study were gathered during the academic year 1992-1993. Enterprises were categorized as either profit or non-profit and then were subdivided according to size of the staff in the office responsible for records management. Profit making enterprises such as manufacturers, wholesalers, retailers, and service providers were included. Non-profit organizations such as churches, philanthropic agencies, public schools, various departments of city and county governments, and various departments of the University of North Alabama were surveyed. Students in the Administrative Office Services Department Records Management classes did the interviewing. Inter-interviewer reliability was carefully controlled through the use of an interview form and training sessions prior to the execution of the interviews. Of the 100 profit and non-profit organizations interviewed, 96.0 percent filed alphabetically, 57.0 percent numerically, 58 percent by subject and 8.0 percent geographically. A combination of these approaches was used by 73 percent of the organizations surveyed; 24.0 percent used manual methods only, and 3.0 percent used computers only. This confirms previous research that approximately 95 percent of all office data continues to be stored on paper.

FAIRNESS IN THE PERFORMANCE APPRAISAL: BEYOND THE REVIEW SESSION.
Henry M. Findley, Dept. of Management, Troy State University, Troy, AL 36082. William F. Giles and Hubert S. Feild, Dept. of Management, Auburn University, Auburn University, AL 36830.

Perceived fairness has been identified as a major determinant of the extent to which performance appraisal systems are accepted by employees. However, little research has been conducted which specifically attempts to identify fair procedures in addition to those used in the appraisal review session. Based on the literature, this cross-organizational study developed appraisal dimensions for the review session and two other contextual domains. The contextual domains were: (a) the structure, policies, and support characterizing the formal appraisal system, and (b) the appraisal-related interactions that occur throughout the year between supervisors and subordinates. Next, the relationships between these appraisal dimensions and the two fairness outcome dimensions were assessed. Procedures from the session and "system" domains were found to most useful for predicting the fairness criteria.

Abstracts

SOCIO-ECONOMIC IMPLICATIONS OF POPULATION GROWTH OF THE UNITED STATES VS. SUDANO-SAHELIAN REGION OF SUB-SAHARAN AFRICA. Eric N. Rahimian and Fesseha Gebremikael, Dept. of Economics and Finance, Alabama A&M University, Normal, AL 35762.

This study is a comparative analysis of the socio-economic implications of demographic changes in the United States and the four countries of the Sudano-Sahelian Region of Sub-Saharan Africa (SSR of SSA) . The latter countries are: Egypt, Ethiopia, Kenya and Nigeria.

Data from the World Bank Development Report and the Statistical Abstract of the United States have been compiled and used as the basis of information. Some demographic variables such as population growth, education and nutritional status for the years 1980 and 1990 have been compared. The United States and the selected SSR of SSA countries have different geographic and socio-economic conditions. The United States is a developed society ,with low population growth, a high standard of living and progressive technological production base. The selected SSR of SSA countries, on the other hand, are plagued with demographic problems, poverty, and malnutrition, which restrain their economic development.

The results of the study indicate that the population of the developing nations (SSR of SSA) is increasing at a rate of 4 percent per year, while the United States population growth is only about 1 percent per year. The United States has more physicians per thousand population, and more and better health care services and hospitals. The SSR of SSA countries do not have a Medicaid plan for the poor and needy, and have limited access to physicians. The school enrollment rate in the U.S. is high, whereas school enrollments in the SSR of SSA countries are too low, and the educational options are very limited. Several recommendations are made to improve the socio-economic conditions of the four countries. Briefly, the population and welfare policies must be strengthened and integrated into the national policy of the nations.

MANAGING GATT THROUGH MULTINATIONAL COORDINATION.

Uchenna I. Elike, Dept. of Economics and Finance,
Alabama A&M University, Normal, AL 35762

Since its inception in 1947, with its many amendments and additions adopted in many phases of negotiations over the years, GATT's membership has grown from an initial set of 22 countries to 116. GATT has proven to be a success in international economic cooperation. During the past 47 years of GATT's history, the world's economy has grown faster than ever. Over the years, however, GATT has experienced a myriad of problems ranging from trade disputes among member countries to many countries sliding toward protectionist trade policies. Unfortunately, GATT has no enforcement powers. Presently, with the down-turn of the world economy following the end of the Cold War and the emergence of strong economic powers in Asia and South America, the need for global economic integration has even become greater. Along these lines, GATT provides the framework by which businesses make global investment decisions. For GATT to become the cornerstone of a new world trading order, member countries should work together in a coordinated effort to enhance the process of global economic integration and growth.

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POOR SCHOOLS, CAPACITY, TASTE, AND TAX EFFORT. James G. Alexander, Department of Economics and Finance, and Marsha D. Griffin, Department of Marketing, Alabama A&M University, Normal, AL 35762. Paulette Alexander, Department of Management and Marketing, University of North Alabama, Florence, AL 35632.

Alabama's system of public school finance is inadequate, inequitable, and unconstitutional. Of singular importance is the general level of underfunding. Low per pupil expenditures are often explained on grounds of the state's low tax capacity, but this is at best only a partial explanation. Whereas 1990 Alabama per capita income was 80 percent of the national average, per pupil public school spending was only 67 percent. According to the ACIR, Alabama's tax effort was only 84 percent of the national average and on a downward trend. Not only is the "poor state defense" insufficient justification for low school spending, it is also counterproductive since educational improvements are essential to modernizing the economic structure and raising income levels. Alabama's historic utilization of the low-skill, low-cost strategy of economic development provides a poor advertisement for this approach as evidenced by the state's low ranking on many economic indicators. Even if it had worked in the past, however, it no longer can as Americans increasingly face competition from extremely low-cost labor in China and elsewhere. Interdistrict comparisons within Alabama indicate that, for city schools in particular, per pupil spending correlates with both capacity (e.g., per capita income) and with taste (e.g., local property tax rates), with capacity playing the larger role. Districts which provide the largest local revenue supplements to state funding are rather consistently characterized by high per capita income rankings (capacity) but low per pupil expenditure to per capita income ratio rankings (taste). Inequities among districts can, of course, be addressed either by state-mandated reductions in expenditure variation or by reductions in effective tax capacity variation through a power-equalization mechanism.

COMMUNICATION NETWORK AUDIT AS A POTENTIAL ASSESSMENT TOOL. Kerry P. Gatlin and William C. Farley, Dept. of Management and Marketing, University of North Alabama, Florence, Al 35632.

This study involved conducting a communications network audit among sixteen engineers and technical employees working for a defense contractor. Each employee completed a questionnaire identifying which colleagues they (1) communicated with most frequently, (2) socialized with most often on-the-job, (3) turned to with work-related problems, and (4) consider to be a part of their immediate work team, regardless of formal assignment. The supervisor of the sixteen person work group was also asked to identify the four employees (top quarter) who were most technically qualified, the four who were the best 'team players', and the four who were the 'peace makers' or 'human relations specialists' among the work team.

A comparison of results indicates that the communication network audit holds a great deal of promise for improving the validity of evaluations where subjective ratings on the part of supervisors are required. The results of such an audit are objective and graphic. Employees who review the results are able to see with little perceptual bias the actual interaction within a work group. In addition to improving the validity of supervisory ratings, the audit also involves co-workers indirectly in the evaluation process, further strengthening the overall process.

Abstracts

How Progressive is "Progressive Discipline"?

Sylvanus S. Ogburia and Bonita M. Conner, School of Business, Alabama A&M University, Normal, AL 35762

Discipline is a management tool used to correct undesirable behavior. It is applied as a means of getting employees to conform to acceptable standards of performance in the workplace. Generally, discipline is imposed in a progressive manner. By definition, progressive discipline is the application of corrective measures by increasing degrees.

In this study, an attempt was made to measure the impact of progressive discipline on productivity among the sampled firms and to ascertain if progressive discipline has changed any since the last ten years. Of the 120 executives pooled, 85% of them said that progressive discipline has, indeed, helped to boost their productivity. In regards to the second research question, 90% of the sampled population said that their progressive disciplinary process has not changed.

Progressive discipline has been around for decades and has worked itself into many different contracts. Because of its longevity, many experts are advocating the use of "the hot stove rule". Still others are recommending team disciplinary measures or letting coworkers deal with infractions rather than the boss. Notwithstanding these suggestions, progressive discipline is still a widely accepted method of maintaining an orderly state of behavior in the organization.

EMPLOYEE PARTICIPATION: MANAGEMENT TOOL OR LABOR

ORGANIZATION?. Dennis W. Gibson Division of Business, Troy State University Montgomery, Montgomery, AL 36103-4419.

While quality may be job one at some companies, quality and participation is word one at other companies. Everyone from industry leaders, to the Business Council of Alabama, to the professional journals of management and human resources, is advancing employee participation and empowerment as the wave of today that will carry the United States business enterprise into the future. The objectives of the quality effort are twofold; first to increase productivity and second to establish and/or open communications channels. The tension between the quality movement and the National Labor Relations Act (NLRA) became apparent in the recent *Electromation* and *DuPont* National Labor Relations Board decisions. Company unions are prohibited by the NLRA. Furthermore, companies are prohibited from interfering with or dominating the activities of workers who want to exercise their rights under the law. The current word: Quality efforts have been held to be labor organizations regardless whether a union is present or not. If the quality effort; 1.) involves employee participation, 2.) has a purpose of dealing with the employer, and 3.) deals with conditions of employment the employer is at risk of violating the NLRA.

Abstracts

THE MACROECONOMY AND ALABAMA. Linda A. Carr, Department of Business, Livingston University, Livingston, AL 35470. Paulette Alexander, Department of Management and Marketing, University of North Alabama, Florence, AL 35632. James G. Alexander and Marsha D. Griffin, School of Business, Alabama A&M University, Normal, AL 35762.

No economy, like no man, is an island. Economies exist in an environment of relations to other economies, and the success of an economy reflects, among other things, how it manages these relationships. To benefit from environmental circumstances, an understanding of economic structures and linkages among economies is necessary. Alabama's economy is in a historic bind between its old low-wage, low-tax basis and the requirements for success in the contemporary global economy, including vastly improved public education. Slow adaptation to changing conditions--e.g., technology, demand, and trade relations--can impede advantageous structural economic adjustments. Moreover, failure to recognize regional ties can lead to failure to promote real interests. During the 1980s, for instance, Alabama's location quotient increased for some declining industries, notably textiles and apparel. Contrary to conventional wisdom, this manufacturing rather than services sector development had adverse wage effects. Furthermore, reliance upon traditional industries encouraged substantial resistance in Alabama to NAFTA. Awareness of inter-regional economic connections, however, might well lead to different public policy positions. Correlation between Alabama and U.S. income growth suggests that strong national economic performance supports the state's interests. Recent differential structural developments, however, have contributed to some degree of de-coupling between the state and national economies. It is also useful to recognize that the Alabama economy is more closely tied to some regions than to others. The Southeast and Southwest stand out as particularly correlated to Alabama; it is therefore likely to be in the state's interest to support policies beneficial to these regions. The Far West and Plains economies, in contrast, correlated much less closely with Alabama's income performance.

NORTH ALABAMA REGIONAL SOCIO-ECONOMIC ANALYSIS. Teshome Gabre, Chukudi Izeogu and Eric Rahimian, Dept. of Community Planning and Urban Studies and Dept. of Economics and Finance, Alabama A & M University, Normal, AL 35762.

The North Alabama Region has a diverse economic climate consisting of agriculture and manufacturing, as well as production of high-tech goods and services. Its geographical location in the Southeast, access to the Tennessee River, and availability of human and physical resources provide great opportunities for development. This paper compares the development of the North Alabama Region with the State of Alabama using selected demographic characteristics and economic variables such as age, race, employment, per capita income, industrial and agricultural growth. The State and county data were compiled and analyzed from the last two decades of Population Census, Alabama County Data Books (1984-1992) and the Statistical Abstract of the United States (1992). Our analysis indicated that the population of North Alabama Region had 5% higher growth rate compared to the State. It was also found that the region accounted for 24.9% of the employment, 37.6% of the cash receipt from farm markets, 32.4% of the value added from manufacturing and 34.9% of the capital investment in the State of Alabama. In general, North Alabama performed better than the State, but some parts of the region lacked a diversified economic base. Balanced socio-economic development will require stimulating investments in these areas.

Abstracts

IMPACTS OF TECHNOLOGY ON HIGHER EDUCATION FINANCIAL OPERATIONS. Paulette S. Alexander, Department of Management and Marketing, University of North Alabama, Florence AL 35632.

Computerized management information systems can and should have a profound impact on the management of financial operations of a college or university in two ways. First, the timeliness, completeness, and accuracy of the data available to and from the system should be significantly improved. Second, the capability to perform detailed analyses allows the reporting, budgeting and planning processes to be dramatically enhanced. During the early history of computerized financial systems, emphasis was placed on the first type of impact -- how to do a rather specific job faster and more accurately. Now the systems have evolved to utilize computerization to find better ways to do other critically needed jobs.

Implications of computerization are seen in changes in the nature of the presentation of and use of financial statements, and in operations management, budgeting and planning of higher education programs. Auditing of financial records of institutions will also be significantly affected by the expanded operation of computerized accounting systems.

The "catch-22" is that acquisition of the hardware, software and personnel to accomplish all that computerization might do is costly in both financial and human resource terms. Although systems are being installed around the country, higher education is in the midst of significant downsizing and the personnel in place are not typically disposed toward retraining for the type of re-engineering necessary to accomplish the goals of a full-fledged computerized "management information system."

PUBLISHED NEWS AND SECURITY RETURNS - AN EMPIRICAL ANALYSIS. William Cheng, School of Business, Tuskegee University, AL 36088

Most previous studies find a negative relations between excess returns and level of information. This paper will examine the impact of the level of published news and portfolio performance by using a new proxy measure -- the frequency of stories reported in The Wall Street Journal. Can a mutual fund manager earn economic profits between 1975-1985 by forming portfolios based on the level of published news? The answer is no based on this study. The findings reject the hypothesis that firms with little news published outperform firms with more news published in terms of risk-adjusted excess returns. The negative relationship between returns and the level of published news exists only when firm size is not controlled for. The relation between the level of published news and returns is either reversed or disappeared when firm size is allowed to interact. This contradictory finding leads us to conclude that more rigorous studies are needed to disentangle capital market anomalies associated with the level of information.

Abstracts

ATTITUDES OF PRIVATE DONORS TOWARD UNIVERSITY GIVING.
Gerald L. Crawford, Professor of Marketing, R. Keith Absher, Professor of Marketing, and Claude A. Hale, Assistant Professor of Computer Information Systems, School of Business, University of North Alabama, Florence, AL 35632.

A study was done on private contributions of more than \$100 to the University of North Alabama. The purpose was to learn more about individuals that made these gifts, their relationships with the school, and how they would like their gift(s) to be spent. Most had attended UNA, and live within 50 miles of the campus. The largest subgroup attended more than 30 years ago. Almost half of the respondents had majored in Business. The largest reason for contributing was "Just started thinking about it (several years ago,) and decided to repay the debt." Almost all had been "properly thanked" for their gift(s). Most rated academics "above average," and campus atmosphere "very good." Alabama, Auburn, and UAH were ranked behind UNA as "most deserving of private community support." Respondents wanted their gifts spent on: (a) more scholarships, (b) more resources for the Business School, (c) new buildings and upgrading of physical plant, (d) more marketing of UNA, (e) increased alumni ties, (f) improved faculty salaries, relations, (g) improved computer offerings, equipment, teaching, and (h) stricter admissions and academic standards.

PREPAID AFFORDABLE COLLEGE TUITION (P.A.C.T.). Charles Baddley, Robert Trimm and Veronica Free, University of North Alabama, Florence, AL 35632-0001.

In 1989 the Alabama Legislature passed the Prepaid Affordable College Tuition (P.A.C.T) program. P.A.C.T is designed to encourage residents to prepay college tuition today for a student that will attend college at some future date. Individuals may purchase a P.A.C.T contract using one of three payment methods. This contract guarantees the payment of up to four years of undergraduate tuition at any Alabama public college or university.

The focus of the paper is to examine all aspects of the P.A.C.T contract. The contract is compared with other investment options that could be used for the purpose of funding college tuition. These comparisons will take into consideration both return on investment and any risk factors involved. Research will also examine how the funds paid into the P.A.C.T program by contract holders are invested by the P.A.C.T fund managers.

Abstracts

MULTIMEDIA: DISCOVERING THE NEW WORLD OF EFFECTIVE COMMUNICATION. Glenda Smallwood, Graduate Student, Sarah Brown, and T. Morris Jones, University of North Alabama, Florence, AL 35632-0001.

Since the beginning of time, man has searched for better ways of communication, and he has recently discovered a "new world" of effective communication: multimedia.

Television and video games attract us far more than books because they "engage" us and allow us to take control of our own learning. In fact, recent statistics have shown that all of us retain 20% of what we hear, 40% of what we see, and 75% of what we see, hear, and do. Studies have also proven that retention rates go up when multimedia (the use of sound, still images, animation, motion video, text, and graphics in a single application) is the medium for the message.

For education, multimedia is the next logical step and is leading the way in an evolution of learning. The use of multimedia transforms students from passive recipients of information into active participants in a media-rich environment. It also allows for greater flexibility in adapting content to suit learning styles and often contains real life experiences that are more meaningful to students. In addition, the blend of different media makes the learning experience richer and more stimulating.

SPREADSHEETS FOR ACADEMICS. Jerry W. Ferry, Dept. of Accounting, Univ. of North Alabama, Florence, AL 35632.

Spreadsheet design can be used to reduce the number of hours needed to program two or more related accounting problems. Accounting problems often consist of two parts. One is to prepare a statement such as an income statement. The second is to find a missing value using algebra. This second aspect means that many different questions can be constructed for every basic concept. Spreadsheets can be used to solve these variations very quickly -- if they are designed properly. The key is to create a UNIVERSAL DATA AREA (UDA) which consists of all the data needed to solve a problem, then solve the problem based on the data in the UDA. For each new variation, only the missing data in the UDA must be calculated, then the spreadsheet will automatically complete the solution. This simple design will save many hours of spreadsheet programming.

Abstracts

ENVIRONMENTALISM AND THE MARKETPLACE. Marsha D. Griffin, Department of Marketing, and James G. Alexander, Department of Economics and Finance, Alabama A&M University, Normal, AL 35762.

The objectives of this research were to: 1) examine current green product usage patterns of consumers, 2) study prevailing attitudes and behaviors of consumers about environmental issues, 3) consider consumers' contemporary stated tolerances of price increases for greener products/policies, and 4) test today's consumers' knowledge about green terms and their trust of product labels and company advertising featuring environmental claims. The data were provided by a 1994 convenience sample of 256 Huntsville, Alabama, consumers. The environmentally friendly products purchased most often were non-aerosol anti-perspirants, pump hair sprays, and energy-efficient light bulbs. Consumers were most likely to consider energy consumption and useful life/updating capacity when purchasing products. Most of the consumers recycle; materials most likely to be recycled were cans and newspapers. Proportions agreeing that they were environmentalists, that they thought the environment had deteriorated over the last decade, and that they felt the environment should be protected at any cost were 37%, 68%, and 62%, respectively. Respondents were asked about their willingness to pay more to protect the environment. Propositions receiving the most support were: paying an extra \$50 in taxes and paying an extra \$600 for a less-polluting car. Most of the respondents knew which terms from a list of terms were most easily defined. They were also aware of the store retailer and manufacturer with the most environmentally sound images. Over 55 percent distrusted product advertising and product labels which make environmental claims. Responses regarding attitudes, price-increase tolerances, and environmental knowledge were indicative of concern with the environment. Behavior patterns, as expected, lagged behind these expressed interests, however, especially where material incentives were lacking.

CURRENT INDUSTRY PERFORMANCE APPRAISAL PRACTICES AND CURRENT EMPLOYEE ATTITUDES. Henry M. Findley, Dept. of Management, Troy State University, Troy, AL 36082.

Many of the new employee involvement techniques implicitly assume that management is already obtaining optimal effectiveness from traditional supervisory practices such as conducting proper performance evaluations and providing timely performance feedback. Recent evidence suggests that this assumption may not be true. The current study found that while some components of the traditional appraisal system are working well there is room for significant improvement in many areas. For example, supervisors are frequently disrespectful to employees during the appraisal review session, criticize employees in front of others, play favorites, and often fail to discipline poor performers. These problems are often more pronounced among women employees. The study also found that often large companies are in as much need of appraisal audits as are small companies.

Abstracts

COMMUNITY CONFLICT CIRCLES: A PROPOSAL FOR THE ELIMINATION OF BLAME IN LABOR DISPUTES. R. Brian Williams and Rick A. Lester, Dept. of MKT/MGT, Univ. of North Ala., Florence, AL 35632

The purpose fo this study was to investigate the existence of any variable responsible for the placing of blame in a labor/management conflict situation. Senior/Junior level business students at a regional state university were used as subjects. The students were given a packet that was divided into three sections. A locus of control questionnaire was presented to see if students were external or internal. Secondly, three hypothetical situations based on National Labor Relations Act Section 8(b)(1)(B) were developed and given to measure blame placing in management/labor conflicts. Lastly, a short demographic questionnaire was administered to determine: sex, age, income, union membership and employment classification. If a variable was found, a plan was to be formulated as a tool to reduce the friction that these conflicts could create. A Community Conflict Circle, designed to provide an avenue to eliminate labor/management conflict, was developed by the author to fulfill this need. It is the hope of the author that this community approach will enable communitites to enjoy a more fruitful existence and expand the productivity of it's businesses.

Determinants in Selecting a Senior Institute by Community/Junior College Students. Ms. Jo Carwile, Ms. Beverly Dyer, Dr. Keith Absher, and Dr. Gerald Crawford, School of Business, Department of Marketing, Management, and Computer Information Systems, University of North Alabama, Florence, AL 35632.

The purpose of this research is to identify determinants that community/junior college students used in selecting a two year college to attend. This is contrasted to the determinants they are using in the selection of the four year college or university they plan to attend. Students were randomly sampled from community/junior colleges in a five county area in Northwest Alabama for this study. Issues investigated included: tuition related issues; scholarships; academic reputations; faculty qualifications; advice of parents, relatives, friends, and teachers; advertising; location; and other issues relevant in their choices.

Abstracts

SCIENCE EDUCATION

Teaching Science Through Multicultural Children's Literature.
Dr. Elizabeth Rhodes Offutt, School of Education, Samford University,
Birmingham, Alabama. 35229.

Every child has a family heritage to learn about. This may be a key to improving not only science instruction but increasing our understanding of ourselves within our complex and interconnected world. Our country is in need for improved instructional methods in the area of science. Science instruction in elementary schools can be greatly enhanced by children's literature. Traditionally, science has been taught using textbooks and worksheets. The content is often broken down into isolated bits of information having little meaning and relevance to the child's everyday life. Children's literature can be used as the foundation of science instruction. Children may be more comfortable following the story line than understanding and applying facts as presented in a textbook. Science can be abstract to a child and must be seen as part of their own life if they are to understand and remember the concepts. A typical story can do this by putting the facts and general concepts into a plot that encourages children to form a hypothesis, predict the outcomes of their experiments, and test their own personal theories. Using multicultural children's literature to teach science concepts provide many unique and valuable educational, social and cultural benefits. According to recent reports on science achievement, native americans, african americans and hispanics were more highly represented in the lowest quartile and more underrepresented in the upper quartile. These statistics reinforce the importance of helping minority children in the area of science. Multicultural children's literature may be the key to motivate and interest many children in the area of science.

EDUCATIONAL OPPORTUNITIES FROM THE ALLIANCES FOR MINORITY PARTICIPATION PROGRAM. Adriel D. Johnson., Department of Biological Sciences, University of Alabama in Huntsville, Huntsville, Alabama 35899.

Alliances for Minority Participation (AMP) are multidisciplinary national programs established to increase the number of minorities receiving baccalaureate degrees in science, engineering, and mathematics (SEM). The AMP program provides opportunities for scholarships, tutorial support, and summer research internships to enhance student retention, provide hands-on research experiences and to increase the number of minority students entering into graduate school. The Alabama AMP is presently comprised of 10 collaborating institutions. At the University of Alabama in Huntsville the AMP program works collectively with several academic units to develop and implement mechanisms which address educational concerns of minority students in SEM.

Abstracts

THINKING ABOUT MISCONCEPTIONS IN MIDDLE SCHOOL SCIENCE.
Ernest D. Riggsby, Joseph D. George, and Dutchie S. Riggsby. Columbus College, Columbus, GA 31907-5645.

Over several years of teaching and preparing papers and reports on that teaching, we have noted many instances and circumstances in which students have responded in discussions, on tests, and in laboratory activities in such manner as to indicate that misconceptions and reversed cause-effect situations have been learned. This brief paper is an effort to illustrate (describe) three of these incidents. It is hoped that we may be able to build into teaching and laboratory involvement some techniques or insurance to prevent or reduce such misconceptions. It is suggested that rushed study, earlier experiences, and acceptance of what may seem obvious with less than desired or required comprehensive study all may contribute to the development of misconceptions. Moreover, a stock of misconceptions held by teachers may be mirrored by their students. The three misconceptions used for illustration are contained within these laboratory involvements: buoyancy (raisins in carbonated water); air current detectors (pin-wheels); and the visible spectrum (examining a prism and sunlight).

HONORS IN CHEMISTRY AT HUNTINGDON COLLEGE - TAXOL, A NOVEL CHEMOTHERAPEUTIC AGENT. Bryan Vining and Massimo Bezoari, Dept. of Chemistry, Huntingdon College, Montgomery, AL 36106.

The Honors in Chemistry course at Huntingdon College provides students with an opportunity to carry out a research project in an area of their own interest. Students benefit by gaining research experience which is comparable to that of a first year graduate student, and by increasing their knowledge in an area of their choice. In addition to a survey of selected literature, the student may be expected to give a formal presentation of the work to the department, or at a local scientific meeting. This project was a survey of the chemistry of Taxol, a chemotherapeutic agent which has been receiving much attention due to its anti-cancer activity and mode of action. Recently, the work of two research groups that have succeeded in synthesizing the molecule was publicized, although a commercially viable synthetic method remains to be developed.

Abstracts

Rural Secondary Science Teachers' Perceived Needs: A Multi-state Survey

William E Baird, Dept. of Curriculum & Teaching, Auburn University, AL 36849-5212. J. Preston Prather, University of Virginia, Charlottesville, VA 22903; Kevin Finson, Western Illinois University, Macomb, IL 61455; J. Steve Oliver, Science Education Center, University of Georgia, Athens, GA 30602

A 100-item survey was distributed to science teachers in eight states in order to determine characteristics of teachers, schools, programs, and perceived needs. Results from 2414 teachers indicate that secondary science teachers perceive the following to be among their greatest needs: (1) to motivate students to want to learn science, (2) to discover sources of free and inexpensive science materials, (3) to learn more about how to use computers to deliver and manage instruction, (4) to find and use materials about science careers, and to (5) improve problem solving skills among their students. In contrast with non-rural teachers, rural science teachers do not perceive much need for help with multicultural issues in the classroom or maintaining student discipline. Rural teachers report using cooperative learning groups in their classrooms less often than non-rural teachers. More rural than non-rural teachers report problems with too many class preparations per day and a lack of career role models in the community. Among all secondary science teachers, the most pronounced problems reported by teachers were [in rank order] : (1) insufficient student problem solving skills, (2) insufficient funds for supplies, (3) poor student reading ability, (4) lack of student interest in science, and inadequate laboratory facilities. Other demographic parameters of teachers will be discussed.

HONORS IN CHEMISTRY AT HUNTINGDON COLLEGE - COLLIGATIVE PROPERTIES OF AQUEOUS SOLUTIONS. Chris Frost and Massimo Bezoari, Dept. of Chemistry, Huntingdon College, Montgomery, AL 36106.

The Honors in Chemistry course at Huntingdon College provides students with an opportunity to carry out a research project in an area of their own interest. Students benefit by gaining research experience which is comparable to that of a first year graduate student, and by increasing their knowledge in an area of their choice. In addition to a survey of selected literature, the student may be expected to give a formal presentation of the work to the department, or at a local scientific meeting. This presentation summarizes the initial part of a study of how various properties of aqueous solutions, including vapor pressure lowering, boiling point elevation, freezing point depression, and osmotic pressure, are affected by dissolved substances. The complete study spans the work of Arrhenius, van't Hoff, Raoult, and Debye and Hückel and how their contributions have affected our understanding of solution chemistry.

Abstracts

USING CONCEPT MAPPING TO ENHANCE STUDENTS' UNDERSTANDING. Thomas E. Bilbo, Dept. of Life Sciences, Univ. of Mobile, Mobile, AL 36663. Teachers who understand Bloom's Taxonomy of Cognitive Objectives realize the importance of developing test questions that require students to use higher level thinking processes. However, a study conducted recently at Boston University determined that science and mathematics textbooks and standardized tests that are currently being used emphasize lower level thinking skills. Ninety five percent of the mathematical items on standardized test were lower level questions that did not require the use of conceptual knowledge or problem solving abilities. David Asubel's Learning Theory stresses that learning is impossible if material is learned by rote, and that meaningful learning can take place only when it is linked to what the learner already knows. J. D. Novak developed concept mapping to allow students to visually represent relationships between concepts. It involves students in active learning since they analyze material and fit new concepts into a framework with material that they already understand.

During Spring of 1993, students at the Univ. of Mobile taking the Introduction to Biology (non-majors) course enrolled in one of four laboratory sections. The students were given a biology pretest and the laboratories were paired so that there was no significant difference in the pretest scores of the study groups. Two of the laboratory sections constructed concept maps of the materials covered during laboratory sessions, and the other two laboratory sections took weekly quizzes. Performance of the two study groups was examined, and students in the concept mapping group were asked to write their opinions of concept mapping and discuss its advantages and disadvantages. The results will be presented during the AAS Annual Meeting.

ESTABLISHING SCIENCE PROGRAMS FOR DIVERSE MIDDLE SCHOOL LEARNERS. Joseph D. George, Ernest D. Riggsby, and Dutchie S. Riggsby, School of Education, Columbus College, Columbus, Georgia 31907.

Collaborative learning and inclusion. Both are here to stay. Both require the Middle School science teacher to work with diverse learners in "one room schoolhouse" type settings. This paper investigates this type setting and offers suggestions for its implementation.

Abstracts

BEHAVIORAL AND SOCIAL SCIENCES

Cosmetics Use and Impression Management. Richard A. Hudiburg, University of North Alabama; Pamela K. Ahrens, Middle Tennessee State University; and Larry Bates, Auburn University

This study investigated cosmetics use and impression management in a sample of undergraduate and graduate female students. The amount and situational and temporal patterning of cosmetics use was measured. Two scales were used to evaluate two different styles of impression management. The Lennox-Wolfe Revised Self-Monitoring Scale (RSM) measured the *acquisitive* style -- used to enhance favored treatment in unknown future circumstances-- and the Concern for Appropriateness Scale (CFA) measured the *protective* style -- the desire to avoid significant losses in social situations.

The subjects in the study reported moderate levels of cosmetic products used and situational cosmetics use, which were in line with previous research. Correlational analyses were performed on indicators of cosmetics use and the impression management variables. It was found that the use of cosmetic products and situational use of cosmetics were significantly correlated with the measure of the *protective* style of impression management -- Concern for Appropriateness. The measure of the *acquisitive* style -- Revised Self-Monitoring Scale -- was not significantly correlated with any of the indicators of cosmetics use. Additionally, cosmetics use was unrelated either to reported self-esteem or social avoidance. To determine whether age affected the relationship of impression management and cosmetics use, a median split of the sample into two age groups (under 23 versus 23 and older) revealed that only younger students adopted the *protective* impression management style.

The Truthfulness of Troy State Honors Students: A Validity Study. Misti Kelley, Fred Gorter, Becky Quandt, and Brian K. Payne, Department of Criminal Justice and Sociology, Troy State University, Troy, AL 36082.

Validity and reliability are just two concepts which social science researchers spend a great deal of time examining. This paper specifically examines the validity of questions asking students to report their ACT scores. The validity of scores on five dimensions is assessed: Natural Sciences, Social Sciences, Math, English, and Total ACT scores. Using data from a national demographic collegiate survey, this research examines the validity of 106 students' responses. Preliminary results indicate that students' responses are accurate on only one dimension: the Total score. Implications are provided in the conclusion.

Abstracts

HUMAN GENOME PROJECT AND ITS EFFECTS ON CRIMINAL JUSTICE. Carolyn Simmons, Dept. of Psychology, Auburn Univ. at Montgomery, Montgomery, AL 36117. William E. Osterhoff, Dept. of Justice and Public Safety, Auburn Univ. at Montgomery, Montgomery, AL 36117.

Mapping of the human genome is probably the most important project medical scientists have ever undertaken. It will enable doctors and scientists to pinpoint the exact location of where a disease or defect in the body originates. Once the defective gene is located, scientists may be able to neutralize it through medication. Most scientists, however, agree that finding cures will come more slowly than finding defective genes. In the meantime, there should be an awareness that this knowledge can potentially cause discrimination in schools, workplaces, insurance companies, and even the courts. Ways of preventing genetic based discriminatory policies and practices that occurred in the past from being repeated in the future were suggested. Potential impacts of the genome project in terms of classical, positivist, and other criminological theories were presented.

ALABAMA RULES OF EVIDENCE: THE IMPACT OF THE PROPOSED RULES.
C. Suzanne Bailey, Dept. of Justice and Public Safety, Auburn Univ. at Montgomery, Montgomery, AL 36117-3596.

The Alabama Supreme Court recognized the need for a compilation of Rules of Evidence. In the late 1980s, the Court appointed an Advisory Committee to draft the proposed rules. As a model, the Advisory Committee used the Federal Rules of Evidence, the Uniform Rules of Evidence, and evidence rules of other states. The Alabama Rules of Evidence with Commentary were submitted in April, 1993, and are currently under review by the Court. This paper explores the proposed rules, the changes the proposed rules will have on the practice of law in Alabama, and the ways in which an attempt has been made to integrate traditional Alabama case and statutory law with the proposed rules. For this exploration, the Alabama Rules of Evidence with Commentary, the Alabama Code, Alabama case law, and articles from the Alabama Law Review have been used. Due to the length of the proposed rules, three major topics, Hearsay, Best Evidence, and Judicial Notice, will be explored in detail.

HOUSING CONDITIONS OF ELDERLY BLACKS IN RURAL SOUTH. William Cheng, School of Business, Tuskegee University. Donald W. Bogie, Dept. of Sociology, AUM. Troy M. McQueen, Dept. of Architecture, Tuskegee University.

Using data from 1980 and 1990 Census, this study analyzes and evaluates the housing conditions of elderly blacks residing in the rural area of three southern states - Alabama, Georgia and Mississippi. Findings indicate that rural black elderly are more likely to rent and to live in older dwelling units that are structurally inadequate than their white counterparts. They are also less likely to have such amenities as complete plumbing, telephones, and a vehicle at their disposal.

Abstracts

THE CURRENT STATE OF THE LAW ON SEXUAL HARASSMENT. Henry M. Findley, Dept. of Management, Troy State University, Troy, AL 36082.

Harassment has increasingly become an issue in the work place that must be addressed and monitored by company management. Under the law there are two identifiable forms of sexual harassment. These are quid pro quo and hostile environment. Quid pro quo is the exchange of favors based on sex. Hostile environment is defined as conduct that unreasonably interferes with an individual's work performance or creates an intimidating, hostile, or offensive working environment. Hostile environment cases are the most difficult to understand and the easiest to commit for seemingly "innocent" behavior. The key determinants of hostile environment cases are: (a) conduct must be unwelcome by the victim and (b) offending behavior is sufficiently severe or pervasive to change the conditions of the work environment to one that is abusive. In general, less severe behaviors such as unwelcome jokes usually must be repetitive in order to constitute sexual harassment and more severe conduct such as unwelcome touching need only occur once to be a violation of the law. Recommendations for employers to limit and prevent liability are provided.

A STATISTICAL ANALYSIS OF THE ALABAMA DEPARTMENT OF CORRECTIONS' BOOT CAMP PROGRAM. Jerald C. Burns, Department of Criminology and Criminal Justice, Alabama State University, Montgomery, Alabama 36101.

The purpose of the paper is to provide a statistical analysis of the Alabama Department of Corrections' Boot Camp Program in relation to its alternatives through the testing of hypothesis pertinent to recidivism, net-widening, cost and ability to reduce prison overcrowding. As a result of the analysis the author concludes that the boot camp is not statistically better as far as recidivism than its alternatives, but that there is no evidence of net-widening. As to cost and reducing prison population, the paper presents realistic data that indicates a savings in both areas. The paper concludes that the boot camp data in Alabama supports the conclusion that it is a viable concept.

INTERSTATE COMPARISONS OF THE DETERMINANTS OF POVERTY IN SOUTHERN UNITED STATES. Uchenna N. Akpom, College of Business and Commerce, Livingston University, Livingston, AL 35470.

Despite efforts by various governments to combat poverty, the levels have remained relatively stable over the years with more than ten percent of American families falling below the poverty level. Nowhere is this more true than in the Southern United States. Policies designed to deal with poverty are doomed if the determinants of poverty are not properly understood. The differences in the nature of poverty between regions also have to be understood. This paper uses a multiple regression analysis to study the determinants of poverty in the Southern United States. A comparison of the relative importance of the determinants is presented.

Abstracts

A DEMOGRAPHIC PORTRAIT OF TROY STATE HONORS STUDENTS.
Cliff Render, Labett White, Tonya Bodenheimer, and
Brian K. Payne, Department of Criminal Justice and
Sociology, Troy State University. Troy, AL 36082.

Much past research has used college students as samples. Interestingly, many of these past studies use students simply because the students provide an easy, captive sample. The current research examines one type of college student--the honors student. Using data from the 1990-1991 National Demographic Survey, this paper paints a portrait of 120 Troy State University honors students. Comparisons with students from the general population will be made. Through this, it is hoped that a better understanding of college students will be provided.

UNDERSTANDING NUCLEAR ARMS PROLIFERATION: TOWARD A TECHNOLOGY DIFFUSION MODEL. Konrad M. Kressley, University of South Alabama, Mobile, AL 36688.

Feeling threatened by the continuing spread of nuclear weapons throughout the world, the major powers have devised a series of treaties, conventions and international agencies to halt the process over the past half century. This legalistic "gun control" approach, however, appears doomed to failure since the spread of nuclear weapons follows a process of diffusion which characterizes the growth and development of other technologies in the world. Specifically, factors such as globalization, modernization, dual use technologies and the personal mobility of scientists and engineers are making nuclear technologies more common place. Fortunately, the evolving post-Cold War international system makes large scale nuclear conflicts extremely unlikely.

CRIME AND CORRECTIONS: TRENDS IN THE 1990'S. William E. Osterhoff, Dept. of Justice and Public Safety, Auburn Univ. at Montgomery, Montgomery, AL 36117.

A brief history of American correctional policies and practices was presented. Corrections also was discussed in the context of social control. Data reflecting the numbers and demographics of individuals currently under community-based and constitutional control were presented. Against this background, anticipated trends in corrections policies, populations, and management practices for the remainder of the 1990's were proposed, as were current and anticipated trends in the extent of court involvement in corrections and the growth of professionalism in the field. Significant problems, challenges, and opportunities for corrections during the remainder of the decade were suggested.

Abstracts

HEALTH SCIENCES

HUMAN INSULIN-LIKE GROWTH FACTOR AND BINDING PROTEIN LEVELS IN MATERNAL SERUM AND AMNIOTIC FLUID DURING THE SECOND TRIMESTER. Da-Chang Chu, Medical Genetics, L.R. Boots, Dept. of OB/GYN, University of Alabama at Birmingham, Birmingham, AL 35294.

Growth is partially regulated by the effects of growth hormone on insulin-like growth factors (IGFs) and their complementary binding proteins (IGFBPs). Since pregnancy represents a complex state of growth, and many complications of pregnancy are the result of abnormal growth, it is important to study growth factors during pregnancy. We studied IGF-1 and IGFBP-3 levels in maternal serum and amniotic fluid from second trimester pregnancies to investigate correlations with growth. Weekly IGF-1 levels from normal pregnancies of gestational age 14-20 weeks were (means \pm s.d.): 31 \pm 29, 24 \pm 29, 37 \pm 29, 29 \pm 29, 34 \pm 32, 26 \pm 28, and 68 \pm 58, respectively. Maternal serum IGFBP-3 levels from normal pregnancies of gestational age 14-18 weeks were 67 \pm 33, 80 \pm 50, 97 \pm 55, 85 \pm 48, and 78 \pm 47, respectively. IGFBP-3 levels in amniotic fluid from normal pregnancies of gestational age 14-20 weeks were 33 \pm 21, 37 \pm 16, 87 \pm 51, 100 \pm 59, 98 \pm 49, 113 \pm 75, and 93 \pm 50, respectively. No patterns were observed for maternal serum IGF-1 in normal pregnancies. However, amniotic fluid IGFBP-3 levels increased to peak levels at 18 weeks and dropped thereafter. Similar patterns of maternal serum IGFBP-3 were observed for whites and blacks although the highest value of IGFBP-3 appeared at the 16th week for the white but the 17th for the black population. Results from 172 amniotic fluids from complicated pregnancies indicated that the majority had diminished IGFBP-3 levels when compared to normal pregnancies. Pregnancies complicated by spina bifida, trisomy 13, 18, 21 and 22, Turner syndrome and Klinefelter syndrome were also studied. Twenty-three out of 31 (74.2%) of these patients had decreased amniotic fluid IGFBP-3 levels.

ASSOCIATION OF NEUROSYPHILLIS WITH AIDS. Robert E. Pieroni, School of Medicine, Univ. of AL., Tuscaloosa, AL., 35487

Since the appearance of AIDS, numerous infectious diseases which health care workers previously infrequently encountered have become more prevalent. Diseases such as tuberculosis which had been declining each year began to rise, and subjects with newly discovered TB are now routinely checked for HIV status. Many AIDS patients are at risk for STD's such as syphilis, a disorder with protean manifestations. In about 30% of untreated syphilitics, late CNS or cardiac disorder, or disease involving other organs, is found. Among HIV positive patients, because of their immunocompromised status, such systemic involvement is likely to be more widespread and severe. We will present the case of a male diagnosed with neurosyphilis and found to have AIDS. The relationship of these two disorders will be discussed in detail, and germane literature reviewed.

Abstracts

PERFORMANCE CHARACTERISTICS OF THE EXPANDED AFP PROFILE PRENATAL SCREENING TEST IN THE BIRMINGHAM OBSTETRICAL POPULATION. Larry R. Boots, Dept. OB/GYN, The University of Alabama at Birmingham, Birmingham, Alabama, 35294.

Prenatal screening for the detection of congenital anomalies has become a routine part of obstetrical care. The measurement of maternal serum alphafetoprotein (AFP) for detection of open neural tube defects (spina bifida and anencephaly) and the combined measurement of AFP, unconjugated estriol (UE3) and human chorionic gonadotropin (hCG) to detect Trisomy 21 have become routine. However, establishing these procedures requires extensive development of normative data for subsequent diagnostic interpretation. These data from 4556 white and 1650 black patients demonstrate the necessity of establishing extensive control data. Median AFP levels ranged from 22.4 ng/ml at 14 weeks of pregnancy to 78.0 ng/ml at 22 weeks for white patients. For black patients, the same range was 24.4 to 90.6. At 14 weeks, black patients have AFP levels 8.9% higher than whites and at 22 weeks, 12.5% higher. Since the rate of change in AFP levels is not constant over weeks of pregnancy and since the weekly medians are higher to start with for blacks, normative data must be established for each race. The patterns of hCG are more complex with blacks having higher values at 14 weeks but lower values at 22 weeks. The decline in hCG levels from 14-22 weeks was 68% for whites and 79% for blacks. Again, separate normative data is necessary. For UE3 levels, both races are similar and do not require separate normal values. In addition to race being a factor, all three markers must be corrected for maternal weight since significant correlations were observed for each. Utilizing these data, 2.70% of the test population was reported positive for open neural tube defects and 4.03% positive for Trisomy 21.

SURVEY OF AIDS POLICIES IN COUNTY GOVERNMENTS. W. J. Jones, DHAP, Medical Univ. of South Carolina 29425. J. A. Johnson and Robert E. Pieroni, School of Medicine, Univ. of AL. 35487

We recently surveyed the county governments of a Southeastern state to ascertain the extent to which they had developed AIDS policies and provided AIDS education for their employees. Of the 32 responding counties, 28 have some formal AIDS policy in place. However, the survey also uncovered significant deficiencies in some aspects of county government AIDS education efforts. Only 50% of counties provided general AIDS education to their employees, and even training for specialized personnel tends to be uneven. In addition, the AIDS education provided is usually not comprehensive. Scientific/medical and legal aspects, and occupation safety issues, are usually examined, but only six counties covered the issues of insurance/benefits or counseling for HIV-infected employees and coworkers. Data indicate that some progress in aspects of AIDS education has been made by public health officials and educators. Nevertheless, the findings make equally clear the pressing need for more complete and relevant AIDS education for the state's county government personnel.

Abstracts

UTILIZATION OF EVALUATION PROCESS. Portia Foster, College of Nursing, Jacksonville State Univ., Jacksonville, AL 36265. Donna Johnson, Graduate Student, Emory Univ., Atlanta, GA 30322

Registered Nurses performances are evaluated informally everyday. Formal evaluations may occur quarterly and/or annually. Socialization into acceptance and participation in the evaluative process is an important part of the professional life of a nurse. The appropriate process of how to perform or complete an evaluation is often neglected in nursing education. The evaluation process should be incorporated into nursing curricula and nursing students should be encouraged to actively participate in both formative and summative evaluations. Evaluation is the systematic process of collecting and analyzing data in order to make decisions. Two phases are included in the evaluation process: the process phase and the product process. Evaluations are given to improve performances. They should be conducted objectively and fairly. Faculty members complete formative and summative evaluations of student nurses. However, only summative evaluations of faculty are completed by students. The investigators recognized that students were only participating in half of the evaluation process. The decision was made to invite senior student nurses in one course to participate in an investigation of the utilization of the evaluation process. A concerted effort was made in the Fall semester of 1993 to improve the student nurses understanding and utilization of the evaluation process. Senior nursing students were introduced to the idea of evaluating faculty members formatively and summatively. Students utilized the evaluation process effectively. The data gleaned from the evaluations were beneficial to both students and faculty.

ANGIOEDEMA ASSOCIATED WITH ACE INHIBITOR THERAPY. F. Wayne Kelly, School of Medicine, Univ. of AL., Tuscaloosa, AL. 35487. Robert E. Pieroni, Univ. of Al. 35487.

Angiotensin converting enzyme inhibitors are widely used because of their beneficial effects in patients with hypertension and congestive heart failure. Several side effects, including cough, bronchospasm and angioedema, have been noted. Recently a 71 year old hypertensive male was referred to us after neurologic evaluation for a possible stroke. The patient had taken enalapril (Vasotec) sporadically the previous year. He was switched to fosinopril (Monopril) 5 months previous to admission. For the past 3 weeks weakness and dizziness had been noted. Mild non-pitting edema of the right side of his tongue had developed prior to admission resulting in dysarthria. A CNS work-up was negative but rapid swelling of his left tongue and marked dysarthria developed. The ACE-inhibitor was discontinued and a calcium channel blocker started. He was given SQ adrenalin, as well as oral antihistamines and prednisone. No respiratory compromise developed. The characteristics of this potentially life-threatening phenomenon will be discussed with special emphasis on prevention, mechanism of action, and possible treatment modalities.

Abstracts

PARENTING AND CHILDRARING ATTITUDES AMONG HIGH SCHOOL STUDENTS: EFFECT OF A CHILD ABUSE PREVENTION UNIT. Elaine Marshall, Ellen Buckner and Charles Childs, University of Alabama at Birmingham, Janet Alexander, Samford University, and Rose Fiorella, Ramsay High School, Birmingham, AL 35294

Reported cases of child abuse in the U.S. exceeded 2 million in 1990. The purpose of this study is to assess changes in parenting attitudes among high school students from before to after a unit on child abuse prevention within students' health class. The Adult-Adolescent Parenting Inventory (AAPI) by Bavolek was used to measure students attitudes on four scales associated with possible abuse: 1) Inappropriate developmental expectations of the child 2) Lack of empathetic awareness of the child's needs 3) High value of physical punishment and 4) Tendency to reverse parent-child roles. The sample consisted of 108 experimental and 54 control subjects, predominantly 9th grade students in one high school which was a competitive alternative school for a metropolitan area. A child-abuse prevention unit was conducted as part of students' health class for the intervention group. The unit included content on developmental expectations of children, management of parental anger and positive parenting techniques. Students scores were evaluated using paired t-tests for pre and post tests. Higher scores indicate less abusive, more nurturing attitudes. All students demonstrated generally healthy attitudes with sten scores in the average range, 4-6. Experimental subjects scores increased more than controls in empathy and summary scales. Low scoring students (n=4) increased more with intervention than without intervention. Recommendations include expanding study to a more diverse school population.

RANITIDINE: EFFECT ON THEOPHYLLINE METABOLISM IN ETHNIC KOREANS LIVING IN CHINA. Charles D. Sands, School of Pharmacy, Samford Univ., Birmingham, AL 35229. Daniel W. Jones, Univ. of Mississippi Medical School, Jackson, MS 39216. Han Hae Lan, Yanbian Medical College, Yanji, P.R. China 133000.

The objective of the study was to determine if concurrent administration of ranitidine (interactor drug), 150mg bid x 7 days, would impair the metabolism of orally administered sustained release theophylline (effector drug), 10mg/kg/day x 7 days, and change pharmacokinetic parameters in healthy ethnic Koreans in China. A double-blind, placebo controlled, two-way crossover, pharmacokinetic drug interaction study design was employed. Steady state plasma theophylline concentration data was evaluated for differences in Cp-ss average, c-max, t-max, kd, vd, and total body clearance between treatment and placebo groups. Six healthy ethnic Koreans (3 males, 3 females, average age, weight, and height: 21.8 years, 55.9 kg, 165 cm) living in China who met the inclusion criteria were enrolled and completed the study. Results showed no statistically significant differences between group means in any of the pharmacokinetic parameters. It was concluded that ranitidine has no effect on theophylline disposition in ethnic Koreans in China.

Abstracts

AGUILERA'S CRISIS MODEL APPLIED TO CAREGIVERS OF ELDERS RELOCATING TO NURSING HOMES. Brenda Riley, School of Nursing, Troy State University, Troy, Alabama 36082.

Aguilera's crisis model was applied to caregivers of elders relocating to nursing homes. The study ascertained the differences between caregivers who experienced relocation of an elder as a crisis and those who did not. Differences were examined in caregivers' perceptions of elders relocating to nursing homes, situational support received by caregivers when elders were in the process of relocating, coping mechanisms used by caregivers, and selected demographic characteristics. The sample consisted of 65 caregivers who were providing care for an elder who was 65 years of age or older. Due to missing data, 46 cases were used in the discriminate analysis to test the hypothesis. The null hypothesis stating that there were no differences in the two groups of caregivers was rejected. The findings indicated that there were differences in marital status, years of school, perception, and ways of coping. Wilks' lambdas and significance levels for the discriminating variables are as follows: primary appraisal, .89, .028; distancing, .83, .028; marital status, .79, .019; years of school, .75, .018; accepting responsibility, .72, .022; and escape avoidance, .69, .019. Scores for situational support did not discriminate between the two groups of caregivers. Since differences were found in the two groups, it was concluded that Aguilera's model was supported by this study.

SUCCESSFUL AGING: DESIGNING A COURSE FOR HEALTH PROFESSIONALS.
Linda A. Streit and Virginia Dare Domico, Georgia Baptist College of Nursing, Atlanta, Georgia 30312

The rapidly increasing older adult segment of our population has been a topic of immense discussion. Persons over the age of 65 currently represent more than 12% of the United States population and by the year 2020 this statistic is expected to rise above 20%. But as people age, are health care professionals preparing persons for the life event changes which occur as one ages. In addition to preparing others, are they preparing themselves?

The purpose of this presentation is to provide a framework for assisting health professionals in designing courses which enhance awareness of aging. The course cited as an example is entitled, "Successful Aging." This course was designed to increase the student's understanding and appreciation of normal aging processes and age related physiological changes. An emphasis was placed on positive developmental attributes and creative approaches that enrich life processes and encourage independence and function. The presentation will encompass teaching/learning methods developed for the course and student generated projects.

Abstracts

EFFECTS OF OXYGEN RADICALS AND CAEV INFECTION ON CAPRINE SERUM ANTIOXIDANT ENZYMES. Shirita Calhoun, Emmanuel Mdurvwa & Peter Ogunbiyi, Schl. Vet. Med., Tuskegee University, Tuskegee AL 36088

Oxygen radicals such as superoxide (O_2^{--}) and hydroxyl (OH^{\bullet}) radicals, have been proposed as playing an important role in various human diseases including ischemic reperfusion injuries, rheumatoid arthritis and AIDS. Virus infections are known to activate the release of these oxygen radicals by blood leukocytes. In this study, we examined the effect of O_2^{--} or caprine arthritis encephalitis virus infection (CAEV) on goat serum antioxidant enzymes' activities. Blood was obtained from normal and CAEV-infected goats by venipuncture. Serum was separated by centrifugation and exposed to O_2^{--} (generated by xanthine/xanthine oxidase) for 15-30 min. Serum superoxide dismutase (SOD) and glutathione peroxidase (GPX) activities were then assayed. Serum clinical chemistry was also examined. Activities of GPX (means +/- SD, U/ml) were significantly reduced by O_2^{--} (56.33 +/- 27.78) or CAEV (75.78 +/- 5.13) when compared to the controls (86.22 +/- 7.4). Both total and CuZn SOD activities were similarly reduced by O_2^{--} or CAEV than in controls. Infected goats showed elevated levels of sorbitol dehydrogenase, alkaline phosphatase and gamma glutamate transferase. The serum levels of these enzymes were reduced by O_2^{--} exposure. Results demonstrate a significant decrease in serum antioxidant enzymes' activities due to CAEV infection or oxygen radical exposure. This may indicate an impairment of a major defense mechanism during CAEV infection or other conditions involving the release of oxygen radicals.

VISUAL HALLUCINATIONS DURING COMBINED USE OF A MUSCLE RELAXANT AND ASA. Robert E. Pieroni, School of Medicine, Univ. of AL, Tuscaloosa, AL 35487. Dan Rodman, Pharm. D., School of Medicine, Univ. of AL, Tuscaloosa, AL 35487

Drug interactions, which play an important role in clinical medicine, all too often go unrecognized. Some medications have a propensity to bind to serum albumin. There may be competition for binding sites when several drugs are used, with resultant higher free plasma levels. Low serum albumin can exacerbate this phenomenon and lead to potentially toxic reactions. A 71 year old male with rheumatoid arthritis who had been taking frequent aspirin developed severe muscle spasms for which cyclobenzaprine (Flexeril) was prescribed. Within a week the patient developed prominent confusion and visual hallucinations. These resolved shortly after discontinuing cyclobenzaprine. Although serum levels of acetylsalicylic acid were slightly sub-therapeutic, those of cyclobenzaprine were over twice the toxic level. The patient had normal renal and liver functions but very low serum albumin levels. We feel that salicylate occupied his limited albumin receptor sites resulting in toxic levels of cyclobenzaprine and the consequent CNS abnormalities. Such an interaction has not, to our knowledge, been previously reported and should be further investigated.

Abstracts

EPIDEMIOLOGY OF ELEVATED BLOOD LEAD LEVELS IN ALABAMA.

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Elevated Blood Lead Levels (EBLL) is a preventable condition that is readily diagnosed and for which practical methods of control are available. Based on the national average (11% to 17%) for children having blood lead levels of 10 mcg/dl or greater, it is estimated that 39,546 to 61,117 children in Alabama are at risk for EBLL. Alabama Department of Public Health's (ADPH) Lead Surveillance System is funded by two separate cooperative grants from the Centers for Disease Control and Prevention (CDC). The goals of the surveillance system are to describe the magnitude of EBLL in children and workers, monitor trends in the occurrence of these conditions, identify new or unrecognized sources of lead exposure, focus public health attention on the problem, and effectively target high risk homes, worksites, and living environments. In 1993 the ADPH received 2,466 reports on 1,792 new cases of children under six years of age and 1,929 reports on 1,096 adults (≥ 17 years of age) with $EBLL > 15$ mcg/dl, an increase of over 47% compared to 1992. This increase is attributed to several factors, including: increased awareness among Alabamians; encouraged testing by Medicaid of EPSDT children; increased testing by private physicians; and improved screening programs and compliance by industries and companies. Whereas children were primarily exposed to lead via paint in old houses, adults were exposed principally at their workplace. The geographic pattern of EBLL cases varied with age. The highest case rates among children under six years of age occurred in west-central and south-central counties, whereas among adults the geographic distribution of cases reflected the location of lead-related industries.

AGGREGATION OF PROTEINS AND ITS PREVENTION BY CARBOHYDRATE EXCIPIENTS. Manohar Katakam and Ajay K. Banga, Department of Pharmacal Sciences, School of Pharmacy, Auburn University, AL 36849.

Aggregation or self association of proteins can result easily, leading to reduced bioavailability or other formulation problems. Moisture-induced aggregation of proteins in solid state and its prevention by carbohydrate excipients for albumin, gamma globulin and insulin was investigated. The likely mechanism of the resulting aggregation was covalent linkages formed due to intermolecular thiol disulfide interchange. A bell shaped curve for percent aggregation was observed with increasing moisture content for bovine serum albumin. When mixed with carbohydrate excipients in a 1:1 ratio, aggregation was reduced for both bovine serum albumin and gamma globulin. For bovine and human insulin, soluble aggregates resulted which were analyzed by a light scattering technique. SEC chromatographic analysis of the aggregated samples indicated that no covalent aggregates were formed. All four carbohydrates excipients minimized the moisture-induced aggregation of bovine insulin, with dextrose and Emdex® being the most effective. In addition to moisture-induced aggregation in solid state, aggregation upon passage through a needle, upon shaking and upon lyophilization were also investigated. The carbohydrate excipients used were found to minimize such aggregation as well.

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BEHAVIORAL AND PHARMACOLOGICAL EFFECTS OF 7, N,N-TRIMETHYL-5-METHOXY-TRYPTAMINE (7,N,N-TMT). John M. Beaton, Dept. of Psychiatry and Behavioral Neurobiology, UAB, Birmingham, AL 35294-0017. Philip E. Morris, Jr., Biocryst Pharmaceuticals, Inc., Birmingham, AL 35244.

Much interest surrounds the study of the indolealkylamines, especially the hallucinogenic ones, and their role as possible endogenous agents in normal and abnormal CNS functioning. 7,N,N-TMT, a new indolealkylamine which combines some of the structural features of the hallucinogens lysergic acid diethylamide, N,N-dimethyltryptamine (DMT), 5-methoxy-N,N-dimethyltryptamine (OMB) and 2,5-dimethoxy-4-methylamphetamine, was tested for behavior disrupting effects and for its ability to bind at CNS receptors. The lethality of 7,N,N-TMT was measured in mice, as was its effect on locomotor activity. The ability of 7,N,N-TMT to disrupt conditioned behaviors (water-reinforced and shock avoidance) was measured in rats. The compound was also tested on a battery of receptor binding assays by the Nova/NIMH screening program. The lethality of 7,N,N-TMT was similar to that of DMT and OMB. The behavioral tests indicated that 7,N,N-TMT did not induce behavior disruption similar to that seen with other hallucinogenic drugs. At low doses 7,N,N-TMT induced stimulant-like effects and at higher doses the effects were more similar to those of a CNS depressant. It was also less potent than the other indolealkylamines. In the binding studies 7,N,N-TMT showed no inhibition of uptake, or receptor binding, for the dopamine or norepinephrine systems. It was, however, a potent inhibitor of serotonin (5-HT) uptake into rat brain synaptosomes. It also inhibited the binding of tritiated ligands at the following 5-HT receptors in the following order of potency: $5\text{-HT}_2 > 5\text{-HT}_1c > 5\text{-HT}_1a$. The slight modification in the structure of OMB, by the addition of the methyl group in the seven position, resulted in not only a reduction in activity, but also a modification of this activity. (Supported in part by NIDA, contract #271-90-7303).

A STUDY OF THE CIRCULATING STATE OF ESTRADIOL AND TESTOSTERONE IN HUMAN SERUM. Tim Wood, H. Downing Potter and Larry R. Boots, Dept. OB/GYN, The University of Alabama at Birmingham, Birmingham, AL 35294.

Testosterone circulates in the blood as either free hormone, bound to albumin or to bound sex-hormone-binding-globulin (SHBG). Estradiol also competes for binding to these proteins and may therefore, regulate testosterone levels. It has also been debated whether free testosterone is the only biologically active form of the hormone or whether the albumin-bound fraction is also active. In seeking to diagnose the cause of hyperandrogenicity and hirsutism in women, generally only the total and free fractions of testosterone are evaluated. Because of the other potential interactions, we studied both hormones in all of their binding states. Serum samples from 105 patients were assayed for total testosterone (103 ± 105 ng/dl), total estradiol (96 ± 61 pg/ml), free testosterone (0.915 ± 1.14 ng/dl), free estradiol (0.905 ± 0.63 pg/ml), SHBG (28.6×10^{-8} M/L), albumin-bound testosterone (43 ± 49 ng/dl or 41.5% of total testosterone) and albumin-bound estradiol (51 ± 37 pg/ml or 53% of total estradiol). Of interest were significant correlations between total testosterone and both free and albumin-bound testosterone. Total testosterone did not correlate with either form of estradiol. The same relationships were true for total estradiol and its binding properties. Other relationships were also studied that might contribute to our overall understanding of testosterone: estradiol relationships.

Abstracts

BACCALAUREATE NURSING STUDENTS: CRITICAL THINKING AND DECISION MAKING. Jan B. Corder, School of Nursing, Northeast Louisiana University, Monroe, LA 71209-0460.

Critical thinking and clinical decision-making skills are accepted attributes of practicing nurses. An exploratory, descriptive design was used to examine the association among critical thinking, clinical decision-making, and selected demographic characteristics in generic baccalaureate nursing students. A convenience sample ($n=195$) in four nursing schools in three states participated in the study.

Critical thinking skills were assessed using the Watson-Glaser Critical Thinking Appraisal. Clinical decision-making abilities were assessed with Jenkins' Clinical Decision Making in Nursing Scale. Demographic data, RNEE score, and GPA were collected with an investigator-designed Demographic Data Form.

Findings indicate that academic and demographic characteristics differentiate beginning baccalaureate nursing students. Two groups, traditional and non-traditional, emerged from analysis of the data. Significant differences found between the groups indicated that the non-traditional group was older, had worked longer prior to beginning nursing school, had a longer time lapse between high school and college, had more children, and scored higher on the clinical decision-making scale than their younger counterparts.

PRODUCTION OF SINGLE-STRAND AND DOUBLE-STRAND DNA DAMAGE BY THE ANTITUMOR ANTIBIOTICS ESPERAMICIN A1 AND C. Rachel E. Harrison and Terry D. Schwaner, Alabama School of Mathematics and Science, Mobile, AL 36604. Peter Dedon, Dept. of Pathology, Mass. Instit. Tech., Cambridge, MA 02139.

The esperamicins are a group of extremely toxic antitumor antibiotics whose toxicity is thought to be derived from their tendency to damage DNA molecules by single-strand and double-strand lesions. Previous studies indicated that esperamicin A1 produced few double-strand lesions, while esperamicin C produced many more. These studies did not consider, however, the possibility of double-strand breaks containing abasic sites, which become apparent after treatment with putrescine. We treated samples of plasmid pBR322 with esperamicin A1 and its analog esperamicin C and compared the ratios of single-strand damage with and without putrescine treatment. Results indicated that esperamicin A1 produced more double-strand lesions than were previously reported and that approximately 80% of these lesions included abasic sites. Esperamicin C was found to produce almost entirely double-strand damage. These results are important for understanding the toxicity of the esperamicins and their potential for cancer chemotherapeutics.

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VERY LOW BIRTHWEIGHT INFANT TEMPERAMENT 6 TO 8 MONTHS OF AGE ON FAMILY UNIT HEALTH. Deborah B. Nelson, D.S.N., School of Nursing, University of Mobile, P.O. Box 13220, Mobile, Al. 36663-0220.

The purpose of this study was to determine if differences in family unit health existed between family units with a very low birthweight (VLBW) infants when compared with full-term infant family units. Thirty-seven mothers of second born children were recruited for study. Included were 15 family units of 6 to 8 month-old VLBW infant and 22 full-term infant family units. An ex-post facto descriptive design was selected to examine infant behavioral style and its relationship of family unit health within the two family units. Barnhill's theory provided the organizing framework for this study and examined family dynamics across six dimensions of health and psychopathology. These dimensions included: (a) individuation-enmeshment, (b) clear communication-unclear communication, (c) stability-disorganization, (d) flexibility-rigidity, (e) mutuality-isolation, and (f) role reciprocity-role conflict. Five dimensions of Carey and McDevitt's (1978) infant temperament scale were employed to examine infant behavioral style and included: rhythmicity, approach, adaptability, intensity, and mood. Full-term infant family units were found to be healthier on all six dimensions of family dynamics; however, statistical significance was not achieved at the .05 level. When the behavioral styles of the two infant groups were compared, statistical significantly differences did not exist on any of the five dimensions of infant behavioral style at the .05 level. Family dynamic scores and behavioral style scores were combined for the two family units and correlations determined. Approach correlated with stability-disorganization ($r = .377, p = .022$) and role reciprocity-role conflict ($r = .466, p = .004$). Adaptability correlated with stability-disorganization ($r = .328, p = .028$) and mood with role reciprocity-role conflict ($r = .403, p = .013$). Nine statistically significant correlation coefficients were generated from this study and included four with clear communication-unclear communication, stability-disorganization ($r = .494, p = .002$), flexibility-rigidity ($r = .426, p = .009$), mutuality-isolation ($r = .792, p = .000$), and role reciprocity-role conflict ($r = .705, p = .000$). Stability-disorganization correlated significantly with mutuality-isolation ($r = .505, p = .002$). Two significant correlations existed with flexibility-rigidity, mutuality-isolation ($r = .347, p = .035$) and role reciprocity-role conflict ($r = .547, p = .000$). By improving one dimension of family dynamics other dimensions are improved thus supporting a system of mutual causality.

DEBILITATING CMV MONONUCLEOSIS SYNDROME IN A PATIENT ON STEROIDS.

Robert E. Pieroni, School of Medicine, Univ. of AL., Tuscaloosa, AL., 35487-0326

Infectious disorders caused by herpes-type viruses such as cytomegalovirus (CMV) and Ebstein-Barr virus, (infectious mononucleosis), are relatively common and usually well tolerated except in immunocompromised patients. Both viruses can result in somewhat similar clinical pictures with hepatitis, atypical lymphocytosis, skin lesions, pharyngitis, cephalgia and malaise. Recently, a 39 year old female presented, on several occasions, to a emergency department with severe headaches and malaise. A head CT scan and lumbar puncture were unrevealing. Previously her physician had prescribed oral steroids for a skin rash. Excruciating headaches, nausea and severe malaise persisted and we were consulted. Lab tests revealed elevation of liver function tests and prominent atypical lymphocytosis. Splenomegaly was noted on physical exam and confirmed by abdominal ultrasound. Both CMV and EBV IgM titers were positive. The patient was treated symptomatically and gradually improved. The potential untoward effects of steroid use in patients with herpes-type viral disorders will be discussed in detail.

Abstracts

TRANSDERMAL IONTOPHORETIC DELIVERY OF PEPTIDE/PROTEIN DRUGS Ajay K. Banga and Ruchira Mitra, Department of Pharmacal Sciences, School of Pharmacy, Auburn University, AL 36849.

Biotechnology-derived peptide/protein drugs cannot be administered by mouth due to degradation in gastrointestinal tract. Also, due to their short lives, repeated injections are required if delivered via parenteral route. Thus, alternative delivery systems are being investigated. These drugs do not normally pass through the skin, but they can be forced into the skin by an imperceptible small electric current, a technique called transdermal iontophoresis. Glass diffusion cells were supplied with less than a milliampere of current via silver/silver chloride electrodes from a software-driven PC based power supply. Transport of amino acids, glycine, phenylalanine and arginine, was investigated across human cadaver skin. Permeation was highest for arginine, which was highly charged at pH used. A higher cumulative transport was observed under anode as compared to cathode or passive transport, for all amino acids. Iontophoretic delivery of the peptide/protein drugs, vasopressin, calcitonin and insulin was also investigated using hydrogel formulations. Iontophoretic transdermal delivery of insulin could provide a noninvasive route for insulin requirements of diabetics. However, several problems need to be overcome for such use. For example, while vasopressin delivery was found to be reversible, insulin formed a depot or reservoir in the skin upon iontophoresis. Modulation of drug delivery was also found feasible by changing the iontophoresis parameters such as current density. This can help to design a biofeedback drug delivery system or to achieve pulsatile administration of peptide/protein drugs.

NMR AND CD STUDIES OF B TO Z TRANSITIONS IN DNA OLIGONUCLEOTIDES. Mary E. Higginbotham, Dept. of Physics, Patricia L. Jackson and N. Rama Krishna, Dept. of Biochemistry, Univ. of Ala. at Birmingham, Birmingham, AL 35294.

Phosphorus NMR and Circular Dichroism Spectroscopy were used to study DNA oligonucleotides ranging from 13 to 17 base pairs in length. These oligonucleotide sequences were designed to facilitate the formation of a B-Z junction under certain experimental conditions. Both NMR and CD spectra of the sequences under low salt conditions (50mM PO₄⁻, 100mM NaCl, pH 7.0) were indicative of predominately right-handed, B-DNA helical structures. Under high salt conditions (50mM PO₄⁻, 4M NaCl, 25% to 70% methanol), the NMR and CD spectra showed some characteristics of the left-handed, Z-DNA helical formation. Some of the sequences produced NMR and CD spectra possessing properties of both right-handed and left-handed DNA formations. When they both exist in the same duplex, a B-Z junction is formed. Experimental conditions which favor the formation of B-Z junctions can also cause aggregation and precipitation which complicate spectroscopic characterization of such junctions. Of the sequences studied, those which form stable B-Z junctions, detectable by NMR and CD, without such complications are identified.

Abstracts

THE ULTRASTRUCTURE OF MOUSE EOSINOPHILS: EARLY EVENTS OF DEGRANULATION? Richard Jones, UA, SOM, Tuscaloosa, AL 35401. Robert Pieroni, MD, UA, SOM, Tuscaloosa, AL 35487. Stephen Kayes, Dept. of Structural & Cellular Biology, USA SOM, Mobile, AL 36617.

Eosinophils are thought to be important immune effector cells in a variety of pathologic states, most notably in helminthic infections. Mice infected with the canine ascarid Toxocara Canis display a peripheral eosinophilia and, in addition, develop an intense eosinophilic pneumonitis. Bronchialveolar lavage (BAL) of such mice can be used to harvest a population of inflammatory cells which is typically 90% eosinophils. We used this method to investigate the distribution of surface Fc receptors on mouse eosinophils and the functional potential of these receptors to induce eosinophil degranulation. We determined that mouse eosinophils express only the type II receptor for IgG. By treating the eosinophils with a monoclonal antibody to this receptor and then exposing treated cells to rabbit anti-rat IgG antisera, we effectively cross-linked the IgG receptors and provided a stimulus for degranulation. Cells with cross-linked receptors were examined for ultrastructural features. Secondary granule concatenation and early exocytic vacuole formation were noted in many cells. However, an unusual attribute of several eosinophils was the presence of perinuclear vacuoles which appeared to be associated with granule processing for exocytosis. To our knowledge, these unusual vacuoles have not been described. Further work to clarify the nature of these perinuclear structures is required.

SUBJECTIVE MENTAL WORKLOAD OF CRITICAL CARE NURSES. Andrea C. Gregg, D.S.N., R.N, College of Nursing, University of Florida, Jacksonville Campus, Jacksonville, FL 32209

Subjective mental workload (SMW) was introduced for study in nursing out of concern that current workload measures fail to capture the cognitive demands of patient care. Information processing theory and research from other disciplines served as the basis for measurement and variable selection. A two-phase study was undertaken. Two delphi survey rounds with ten nurse experts yielded a content valid instrument (CVI = 1.00), Nursing TLX. Cronbach alpha was subsequently assessed at 0.82. A descriptive correlation study was conducted to examine the relationship among SMW, experience, and education of cardiovascular critical care registered nurses. Seventy nurses reported an average SMW of 4.3 [1=low, 10=high] following the first four hours of nursing care to patients with select diagnoses. No significant ($p < .05$) relationship among SMW, education, or experience was found. Post hoc analyses revealed significant relationships between SMW and diagnosis, volume of assigned patients, and number of days off prior to measurement. Implications of these findings for nursing workload measurement and work redesign are discussed.

Abstracts

PROLACTIN LEVELS IN MATERNAL SERUM AND AMNIOTIC FLUID DURING THE SECOND TRIMESTER OF NORMAL AND ABNORMAL PREGNANCIES. Melissa D. Kahsar, Medical Genetics, Larry R. Boots and Katharine Wenstrom, Dept. OB/GYN, The University of Alabama at Birmingham, Birmingham, AL 35294.

The role of prolactin during pregnancy has not been studied in sufficient detail to draw conclusions related either to prenatal prediction of pregnancy complications or to its role in abnormal development. In this study we measured prolactin levels in matching maternal serum and amniotic fluid from 616 normal and 189 complicated pregnancies between 14 and 20 weeks. Normal ranges were established and used for comparison with complicated groups. Comparisons were also made between pregnancies with male or female fetuses. Median values (ng/ml) comparing blacks and whites from 14-20 weeks of gestation in amniotic fluid were 1036/964, 1571/1478, 1696/1832, 3880/2509, 4048/3157, 6055/3828, 6388/3608 and in serum 40/28, 41/30, 52/36, 57/36, 59/47, 58/37, 48/36. Blacks had consistently higher values than whites. When pregnancies bearing male or female fetuses were compared, males generally had lower values but ratios varied dramatically with gestational age. Most of the pregnancy complication groups had lower prolactin levels than did normals, including Trisomy 21, 47XXX (amniotic fluid only) and Turner's syndrome. Notable exceptions were spina bifida, 45X0/46 XY and Trisomy 13 and 15 (the latter three in amniotic fluid only). While these preliminary data suggest that certain genetic disorders may be associated with abnormal prolactin levels, further study will be necessary to determine whether prolactin levels would be useful for prenatal screening.

HYPOBETALIPOPROTEINEMIA: LITERATURE REVIEW AND CASE REPORT. Edward B. Perry, School of Medicine, Univ. of Ala., Tuscaloosa, AL 35487. Robert E. Pieroni, MD, School of Medicine, Univ. of Ala., Tuscaloosa, AL 35487

Hypobetalipoproteinemia is an autosomal codominant disorder in which the plasma concentrations of apolipoprotein B and LDL, which are recognized risk factors for the development of arteriosclerotic coronary heart disease, are decreased or absent. Heterozygotes are characterized by relatively low apo B and LDL-cholesterol levels and are usually clinically asymptomatic, while homozygotes have extremely low or undetectable apo B and LDL-cholesterol levels and may exhibit fat malabsorption, acanthocytosis, retinitis pigmentosa, and neuromuscular degeneration. We shall present a case study of a family whose members have lipoprotein, cholesterol, and triglyceride levels consistent with hypobetalipoproteinemia, and describe recent progress in research on the disorder, which has focused on delineation of apo B gene mutations and alteration of lipoprotein metabolism.

Abstracts

A PROSPECTIVE STUDY COMPARING THREE FLUSHING SCHEDULES TO MAINTAIN HICKMAN CATHETER PATENCY. Joan M. Lundebjerg, Wilma Geels, Madeline Harris, Richard Taylor, and Lindsey A. Trammell. UAB Comprehensive Cancer Center, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

Although central venous catheters are in widespread use for cancer patients, no research based standard method currently exists for maintaining the patency of these catheters. The purpose of this randomized prospective study was to compare three catheter flushing regimens using heparinized saline: weekly flush, twice weekly flush, and three times weekly flush. The study involved 35 patients with Hickman catheters. Three partial occlusions and one total occlusion occurred in the group flushing weekly. No occlusions resulted in the group flushing twice weekly, while one partial occlusion existed in the three times weekly group. No statistically significant difference was evident among the three groups. However, when the twice weekly and three times weekly flushing groups were combined and compared with the once weekly flushing group, the p value 0.052 was slightly significant at a 0.05 level. Given these numbers, the researchers suggest that the pilot study be repeated using a larger sample size in an effort to obtain reliable statistical significance.

CONTROVERSIES IN CANCER. Richard Jones and Robert Pieroni, Depts. of Medicine and Family Medicine, UASOM, Tuscaloosa, AL. 35487.

It is a commonly held belief by many, including medical professionals, that cancer results from defective immune mechanisms and, further, that disease may be eliminated from cancer patients by appropriate immune stimulation. Phenomena such as spontaneous tumor regression, efficacy of immune-stimulating drugs in treating cancer patients, and the increased incidence of cancer in immunocompromised patients are cited as proof of these suppositions. However, alternative explanations exist for these observations. It remains debatable whether the hypothesis of immune surveillance adequately accounts for the growth or inhibition of transformed cells in a given individual.

Abstracts

REGULATION OF VASCULAR ENDOTHELIAL GROWTH FACTOR SECRETION IN BRAIN TUMOR CELLS. Corey K. Goldman, Jui-Chang Tsai and G. Yancey Gillespie, Division of Neurosurgery, UAB, Birmingham AL 35294.

Glioblastoma multiforme (GBM) is the most common and malignant primary brain tumor in humans. New blood vessel growth or angiogenesis is a prominent histopathologic feature of this tumor that may contribute significantly to the inexorable growth that characterizes these uniformly fatal neoplasms. Blockade of new blood vessel growth is a potential therapeutic option that should slow tumor growth.

We have identified Vascular Endothelial Growth Factor (VEGF) in 9/9 GBM cell lines and in most surgical specimens. We sought to determine the regulation of VEGF secretion at the cellular level in U-105MG, a well characterized GBM cell line. Three peptide growth factors, Epidermal growth factor, basic Fibroblast growth Factor and Platelet Derived Growth Factor BB were all capable of enhancing VEGF secretion by U-105MG cells ($p < 0.01$). In contrast, Insulin and Platelet Derived Growth Factor AA had no significant effects on VEGF secretion. These results suggest that secretion of VEGF from GBM cells could be coupled to specific polypeptide-mediated growth of GBM cells via activation of growth factor receptors.

Using relatively specific second messenger inhibitors, we have demonstrated that Protein kinase C but not PKA, signaling pathways are involved in growth factor mediated VEGF secretion. As would be expected, tyrosine kinase inhibitors also had potent inhibitory effects on stimulated VEGF secretion and is consistent with EGF, FGF and PDGF BB signals being transduced via tyrosine kinase receptors.

COMPUTER-ASSISTED INSTRUCTION IN TEACHING HEALTH-RELATED MATHEMATICS. Allison B. Jones & Glenda Davidson, Troy State University School of Nursing, Montgomery, AL 36104.

Computer use in the classroom and as a part of self-directed learning is increasing in many fields, including nursing. The authors describe the use of computer-assisted instruction to facilitate mastery of health-related mathematics in an Associate Degree nursing program. Statistical analysis was performed to determine if computerized instruction or the traditional lecture approach was more effective for teaching this content.

Abstracts

ENGINEERING AND COMPUTER SCIENCE

WIDE BANDGAP SEMICONDUCTOR PLANAR ELECTRON EMITTERS.
M. M. Basha and K. Das, Dept. of Electrical Engineering, Tuskegee University,
Tuskegee, AL 36088.

Electron emission from planar semiconductor structures have been demonstrated by a number of research groups over the last thirtyfive years. For this purpose various devices structures, namely forward biased p-n junctions, reverse biased junctions operating at avalanche, and npn diodes, have been employed. Generally, electrons are accelerated by the internal electric field established in a device. Those electrons reaching the surface with enough kinetic energy to be able to surmount the surface work function, will be emitted into vacuum. In early research, Si and SiC reverse biased p-n junction diodes were employed. When the device is biased at avalanche breakdown point, carriers are multiplied by impact ionization and gain kinetic energy from the reverse bias field. Using a suitable bias, an npn diode can be operated in a reach through mode with the np junction acting as an injecting junction and the pn provide the accelerating field. The emission efficiency of early devices were low. In order to enhance emission, the solid surface is normally coated with about a monolayer of a low work function material, such as cesium or cesium oxide. Using an AlGaAs/GaAs doped barrier n-i-p-i-n structure with a delta doped p layer, Mishra and Jiang reported an emission efficiency of 1% with a cesiated surface. With narrow bandgap semiconductors a substantial proportion of the carriers are transported by tunneling through the bandgap in the accelerating region. These carriers are unlikely to have enough kinetic energy to be emitted. The use of wider bandgap maretials is expected to reduce the magnitude of the tunneling current, therefore, wide bandgap materials, such as SiC, GaN, GaP, and diamond are expected to yield higher efficiencies of emission. With the use of wide bandgap semiconductors the need for cesium coating of the surface may also be eliminated.

THE REGISTERED LAND SURVEYORS OF ALABAMA MEET THE SPECIFIC REGULATION OF MINIMUM TECHNICAL STANDARDS. James V. Walters, Dept. of Civil Eng., Univ. of Ala., Tuscaloosa, AL 35487-0205

Last year, 1993, was the time when every Registered Land Surveyor (R.L.S.) who practices in the state of Alabama was brought face-to-face with the realities of the specific regulation that the codified adoption of Minimum Technical Standards (MTS) has mandated in his professional practice. The leaders of his professional society had worked many years for the adoption of MTS and for the requirement for mandatory continuing technical and professional education of all registrants who practice in the state. It is apparent that many or perhaps most of those affected favored the amended regulations, but like them or not each registrant was introduced to them efficaciously. The author reports the essence of the developments that caused the code amendments and the interworking of the continuing education requirements with the introduction of the expected effects of the MTS adoption.

Abstracts

OBJECT ORIENTED NEUROGENETIC SYSTEM FOR EVOLVING FEEDFORWARD NEURAL NETWORKS. Mikal Keenan, Dept of Computer and Information Science, Univ of Alabama at Birmingham, Birmingham, AL 35294. keenan@cis.uab.edu

Most of the heuristics for neural network (NN) design are limited to symmetrical, fully connected architectures and they do not necessarily yield minimal or economical application specific solutions. Strategies for solving such NN design (also training) problems use trial and error. Trial and error can be prohibitively expensive with no guarantee of success. Automation of NN design and training might yield more economical solutions. Genetic search (GS) is a computational analogue of Darwinian concepts which may provide the necessary automation. Robust and capable of solving problems with a large number of variables and constraints, GS is suitable for use with any problem which can be represented by an objective function and data structures which a genetic algorithm (GA) can manipulate. Using GS to automate NN design and training the investigator may be able to operate at a higher level of conceptualization, unhindered by problem semantics (NN-design and training constraints) and possibly finding more accurate and unexpected results. GS may yield NN designs that are more general and economical (e.g. asymmetric, not fully connected). Using GS to train NNs, it may also be possible to use training functions that are not continuously differentiable, weight optimization procedures that are not calculus-based and discontinuous performance criteria. Previous exploratory research and the results of research done by others corroborate these suggestions.

Planned research will incorporate domain-specific knowledge into a dedicated object-oriented *neuro-genetic* system to allow GA manipulation of both the design and training phases of NN development. This system will accommodate investigation of strategies for automating NN design by evolving architecture, data flow and neurodynamics (*structural machine learning*) and investigation of NN training as parameter and weight adjustment (*numerical machine learning*). Investigations may include parallel implementations and application of GS (either solo or in collaboration) to connectionist models other than those of the feedforward type.

SEMANTIC DATA MODEL OF APPROXIMATION FOR TEMPORAL DATABASES. Yin Lin and Susan Vrbsky, Dept. of Computer Science, Univ. of Alabama, Tuscaloosa, AL 35487.

A real-time system has specific time constraints for the processing of a transaction as well as a temporal dimension to its data. The areas of temporal databases and approximate query processing for satisfying time constraints have so far been researched separately. In this paper, we propose a semantic data model that integrates the areas of approximating query processing and temporal data models to provide meaningful approximate answers that address the temporal dimension of the data and satisfy the timing constraints of the query. Our model includes two levels. The underlying level is realized as 1NF temporal relations to include a "lifespan" -- the subset of time the values of data objects in the database are valid. We also present a relational algebra that includes a set of time-oriented operations. On a higher level, the approximate query processor maintains an object-oriented view of the temporal relational database and can be implemented with little changes to this underlying relational architecture.

Abstracts

ACOUSTIC IMPACT TECHNIQUE FOR IDENTIFICATION OF FATIGUE DAMAGE IN COMPOSITE LAMINATE. A. Haque and P. K. Raju, Department of Mechanical Engineering, Auburn University, Auburn, AL-36088.

Acoustic Impact Technique has been investigated in identifying fatigue damage in graphite/epoxy, thermosetting and graphite/Peeck, thermoplastic composite laminates. The use of the Acoustic Impact Technique(AIT) has shown encouraging results by previous investigators in identifying defects like delamination and disbonds in honeycomb structures. Very limited work has been reported in the literature on the utility of AIT in identifying fatigue damage in laminated structures. The AIT method involves striking the structure with an instrumented impactor in the region of interest and recording the time history of the impulse. The response of the signals received from both good and defective zones of a specimen were analyzed in the time and frequency domains. In the present investigations, the specimens were tested both under tension-tension and tension-compression (reverse fatigue)cyclic loading conditions at three stress levels. Fatigue damage was observed in the specimens at various stages of cyclic loading. Acoustic impact technique was applied to identify the extent of damage through studies on the force amplitude, the pulse width and frequency characteristics. Sensitivity of the Acoustic Impact Technique was also investigated by comparing the results with ultrasonic C-scan technique.

OBJECT-ORIENTED APPROACH TO NEURAL-NETWORK ARCHITECTURE. Samuel Joe Rogers, Department of Computer Science, University of Alabama, P.O. Box 870290, Tuscaloosa, AL 35487.

Object-oriented languages like C++ provide several new approaches to the design and implementation of neural-network architectures. However, many of the current object-oriented implementations of neural networks do not fully exploit the object nature inherent in most neural-network designs. These implementations focus on abstracting the network as a whole while overlooking the basic elements that could be used to create the network. This study looks at a different approach to creating neural-network architectures. One set of base classes is used to create a variety of network architectures, such as backpropagation, Kohonen self-organizing, and recurrent backpropagation. Instead of building from the network down, the networks in this study are built from the base element (or node) up giving the user much more control over the network design.

Abstracts

HIERARCHICAL SCHEME FOR THREE-DIMENSIONAL SURFACE RECONSTRUCTION. Yun Wang, Department of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL 35294

Three dimensional surface reconstruction is very useful in medical imaging, geometric modelling and scientific visualization. Given some raw data, either volume data (CT or MRI), implicit function, or scattered data over three-dimensional space, the problem of surface reconstruction is to interpolate or approximate the surfaces from those data so that one can have better visualization of the surfaces, or even more, manipulate the surfaces. Several surface reconstruction methods are implemented to obtain the intermediate surface representation — polygonal approximation, and a computer graphics pipeline is applied to get the rendered surfaces. A hierarchical scheme is developed here for those surface reconstruction techniques. It uses the hierarchical data structure octree to maintain its multilevel data so that if one level of the surface is not satisfied, a finer or coarser level of the surface will be constructed according to the subdivision criteria such as curvature or number of polygons. Curvature information is color plotted on the constructed surfaces. The hierarchical scheme increases the accuracy of constructing highly curved surface or sharp edges and keeps the topological correctness with respect to the interpolation scheme applied in the subdivision or resampling of the original data. Interpolation scheme plays an important role in discrete data such as volume data since no other information is given between any two data points and any reasonable interpolation scheme can be assumed. Only under an assumed interpolation scheme a correct surface can be constructed with respect to that interpolation scheme and a different interpolation scheme might be suitable for a different surface reconstruction technique. The hierarchical scheme also provides a multilevel visualization of the surfaces.

CEPSTRUM ANALYSIS APPLICATIONS IN THE NON DESTRUCTIVE EVALUATION OF STRUCTURES. Bradley A. Miller and P.K. Raju, Dept. of Mechanical Eng., Auburn University, Auburn, AL 36849.

This paper describes a technique for determining the location and severity of damage in simple structures from vibration testing information. Information available from vibration testing, such as the structure's dynamic characteristics, uniquely characterize the structure's behavior. Valuable information about the location and severity of damage to a structure can be determined by analysis of the change in the dynamic characteristics of the structure that occurs as a result of the damage. The procedure put forth in the paper uses a non-linear signal processing technique called cepstrum analysis. The complex cepstrum of a vibration signal is defined as the inverse Fourier Transform of the logarithm of the Fourier Transform of the vibration signal. As a result of the properties of the logarithm function in its definition, the complex cepstrum of the vibration signal from an excited structure gets separated into two additive components, the input cepstrum and structural response cepstrum. For many practical mechanical systems, the input cepstrum is shorter than the structural response cepstrum and can therefore be extracted from the cepstrum of the measured vibration signal leaving a partial segment of the structural response cepstrum alone. Consequently, important information about the dynamical characteristics of the damaged structure can then be extracted from the structural response cepstrum segment leading to knowledge of the location and severity of the damage. In conventional techniques, full knowledge of the input excitation force was necessary to determine the structural response. The advantage of this technique over conventional techniques is that much less information is needed about the input. As a result, cepstrum analysis will find use in applications in which obtaining knowledge of the excitation force is impossible, such as on space vehicles.

Abstracts

COGNITIVE PREDICTION SYSTEMS: AN APPLICATION OF SOFT COMPUTING TO ECONOMY PREDICTION. Antony Satyadas, Department of Computer Science, The University of Alabama, Tuscaloosa, AL 35486-4983. email: antony@cs.ua.edu

Our recent research explores a cognitive soft computing framework that allows a Fuzzy Multi-Criteria Decision Making (FMCDM) committee to dynamically evaluate various sources of prediction (Flexible Intelligent Systems). Soft computing involves the application of fuzzy logic, connectionist models, genetic algorithms, chaos theory, and so on to manage uncertainty. Typical prediction models include connectionist recurrent variant feed forward time series memory modules, similarity and commonsense reasoning modules, and chaotic time series. The FMCDM committee uses fuzzy reasoning and evolutionary learning to make a group decision regarding the best prediction. Significant in this research effort of understanding and developing predictive models is the importance of human cognitive processes. The predictive nature of these cognitive processes is often hidden in its implicit profile. This paper focus on the relevance of cognitive processes in dynamic prediction. An overview of soft computing, Flexible Intelligent Systems (FIS), and similarity based reasoning is first presented. The predictive properties of cognition are then enumerated. The importance of similarity and trends are explored using the business cycle indicator data set. We conclude the study with a discussion of future directions.

PARALLEL MATCHING IN PERMUTATION GRAPHS AND COGRAPHS. Hiryoung Kim and Alan Sprague, Dept. of Computer and Information Sciences, Univ. of Alabama at Birmingham, Birmingham, AL 35294.

A graph is an important data structure for various situations that can be represented by a set of points and their connecting edges including maps, scheduling, electrical circuits, etc. Consider two parallel lines where the top line consists of n points labeled $1, \dots, n$ and the bottom line has n points whose labels are the permutation of $1, \dots, n$ and n straight line segments are drawn, each between a top point and the bottom point having the same label. The vertices of a *permutation graph* are the line segments and are adjacent if and only if the line segments intersect. Permutation graphs find many applications including routing problems in VLSI design. A *matching* in a graph is a subset of its edges such that no two edges share the same vertex. A *maximum matching* problem is to find the largest possible set of matching. There have been substantial studies on matching in various classes of graphs. Though reasonably good sequential matching algorithms have been published, developing the corresponding parallel algorithms has been a challenge. In this paper, we study sequential and parallel matching on permutation graphs as well as on their subclass *cographs*. Olariu and Lin have recently provided a work optimal parallel matching algorithm on cographs. We present an alternative approach for the problem. The author has been supported, in part, by the Alabama Academy of Science grant.

Abstracts

DIAMOND SEMICONDUCTOR DEVICE PROCESSING. C. Munjoma, M. Teklu, and K. Das, Dept. of Electrical Engineering, Tuskegee University, Tuskegee, AL 36088.

It is well documented that diamond has a number of interesting electronic and mechanical properties that make it potentially well-suited for the fabrication of devices operating at high temperatures, speeds and power levels. Although, high quality heteroepitaxial diamond films on inexpensive substrates are essential for wide scale device fabrication research, currently only randomly oriented or aligned polycrystalline material can be grown. Films with p-type conductivity can be obtained by in-situ doping with B during growth. Boron doping by ion implantation has also been achieved, although activation depends critically on the implant temperature and the anneal procedure employed. Reproducible n-type doping for diamond has not been accomplished. However, donor activity arising from residual implantation damage has been observed. Ohmic contacts can be routinely fabricated by introducing a high surface concentration of B and a Ti or TiC metallization. Rectifying contacts on chemical vapor deposition grown polycrystalline or epitaxial films cannot be easily fabricated by direct deposition of metal films. However, rectifying contacts on naturally occurring semiconducting crystals may be obtained by depositing a film of any conducting material. In spite of the problems mentioned above, field effect type transistors have been demonstrated both on epitaxial and polycrystalline diamond films. Electron emission from diamond crystals at room temperature has been demonstrated using a p-n junction where the n material was created by donors contributed by implantation damage . Electron emission has also been obtained from diamond using a primary electron beam excitation.

DYNAMICALLY DEVELOPING A NEARLY OPTIMAL FEED FORWARD ARTIFICIAL NEURAL NETWORK ARCHITECTURE USING MINIMAL RESOURCES. Nikhil A. Umrani, SBS Corporation, Birmingham Al 35205.

The Backpropagation (BP) neural network is among the most widely used and researched paradigms for feedforward neural network training. A major drawback of the BP algorithm is the large amount of time required for training the network. This excessive training time is directly related to the computational intensity of the algorithm. A second problem is that the standard BP algorithm does not determine the optimal network architecture for a given task. A parallel processing strategy for feedforward network training and optimal architecture network determination is reported in this paper. The strategy is based on a computationally less intense search algorithm which is executed in two phases. The first phase deals with initial learning rate selection, and the second phase consists of multithread search which includes learning rate adaptation and hidden unit augmentation.

Abstracts

TEACHING AND THE "GREEN MACHINE": THE COMPUTER AND TECHNOLOGICAL ECOLOGY. Dutchie S. Riggsby and Ernest D. Riggsby, Columbus College, Columbus, GA 31907-5645.

There is hardly a point in time when someone is not expounding on the negative nature of the impact of technology on the environment, culture, family life, and economics. At present, we are being bombarded with concepts of the value, and lack of value, of the computer. Most users, and even some manufacturers are looking at the need to be concerned with health hazards and pollution being generated by this techno-wiz machine. In an effort to explore this concern, the nature of the computer, its use, and the distribution of it, and all its peripheral items are considered in the observations of the researchers. This is a project directed at determining ways to reduce the impact on health and environment ... from chip to 'nuts. At present, the impact of the computer in this framework is relatively new as a topic within a very old area of concern therefore, finding specific articles is a matter of search and not just looking up "Green Machine". In teaching "Green Machine" ecology, the teacher will find that the use of tidbits of facts from many sources is the most appropriate approach to be considered in relation to this topic.

GENETIC ALGORITHMS FOR TRAINING FUZZY NEURAL NETS. P. V. Krishnamraju, Kevin D. Reilly, Department of Computer and Information Sciences, University of Alabama at Birmingham, Birmingham, AL 35294. James J. Buckley, Mathematics Department, UAB, Birmingham, AL 35294. and Yoichi Hayashi, Department of Computer and Information Sciences, Ibaraki University, Hitachi-shi, Japan 316.

This paper is concerned with the development of learning algorithms for multi-layer feedforward neural networks whose weights are given as triangular fuzzy numbers. The fuzzy neural network with the proposed genetic-based learning algorithm can map a fuzzy input to a fuzzy output defined by the extension principle. The training data for the fuzzy neural net is generated by function $\bar{T} = F(\bar{X}) = \bar{X}$, where \bar{X} and \bar{T} are triangular fuzzy numbers. The trained fuzzy neural net recognized the training data perfectly (error=0.0) and test data with a mean error of 9.88×10^{-14} .

Acknowledgements: The author wish to thank Alabama Academy of Science for the grant support.

Abstracts

SAMFORD UNIVERSITY'S GLOBAL CENTER: A PUBLIC ACCESS GIS. David Young, The Global Center, Samford University, Birmingham, AL 35229.

The Global Center of Samford University is now in the process of developing a global database system for use by students in every field of study. Arcview software will be used along with several of the packaged databases sold by ESRI. The databases and software will be customized to create an environment that is easy to use and understand by all, and for integration with some statistical databases that we already have. The Global Center was created to facilitate relationships and the exchange of information in the Christian missions community. I will be discussing the Global Center database system from idea to implementation.

TEMPORARY EARTH-RETAINING STRUCTURES FOR ARCHAEOLOGICAL EXCAVATIONS.
David M. Painter, Jr., P.E., City Engineer, City of Jackson, AL.
36545.

Temporary Earth-Retaining Structures for Archaeological Excavations presents a comprehensive summary of actions required to examine, survey, review, analyze and prepare site conditions for safe and efficient temporary earth-retaining structures. Certain types of these structures suitable for archaeological excavations are covered with case studies to demonstrate proper use. The new OSHA Excavation Standard is reviewed. Erosion and sediment controls are examined including the use of Best Management Practices (BMPs). A guide to excavating near trees and utilities is included and provides additional information about safe excavation practices.

SOFTWARE REUSE THROUGH CODE WRAPPING. Vikas K. Kamat, ProSoft Inc., 320 Crawford Street, Fairfield, AL 35264.

Software re-engineering remains one of the software industry's major challenges. As organizations attempt to move ahead with more sophisticated and cost effective software and hardware solutions, the transition is marred by typical problems of huge costs of program re-writes, environment and model incompatibilities, and costs of training developers. Code wrapping involves re-packaging a software system to look and behave like a module or subsystem component in the re-worked system. Several techniques and issues involved in this re-packaging are discussed including examples and potential new areas of application.

Abstracts

ANTHROPOLOGY

ARTIFACT ANALYSIS OF RED FOX MOUND. Orval E. Shinn. Dept. of Anth., Univ. of Ala., Tuscaloosa, AL 35487.

The University of Alabama's 1992 excavations of the Red Fox Mound (1LI15) revealed a very regular 35.5 meter long, 15.0 meter wide 2.2 meter high rectilinear remnant with distinct northwest and northeast corners, having an internal structure composed of ten sequent, rectilinear and artifact containing building layers capped with an artifact free layer of tan sandy-clay loam. Each building layer contained shell, but each varied slightly in color, texture and the amount of shell it contained. Each was also separated from its familiar neighbors by a discontinuous, line of fine crushed shell fragments. One, possibly two, oval, clay-capped, log-covered, and clay-lined pits resembling Copena precedent burial chambers, were found beneath the first building layer near the mound's northeast corner. In our laboratory analyses we attempted to determine the mound's authorship. We found that the majority of the ceramics were grog and limestone tempered but that minor amounts of plain shell tempered pottery were included in all building stages. This leaves us with two possibilities: (1) the mound was constructed by Mississippian stage peoples from a mixture of Mississippian and Woodland stage debris or (2) the mound was built by Woodland stage inhabitants who manufactured minor amounts of plain shell tempered pottery. The unequivocal assignment of mound authorship must therefore await a careful excavation and analysis of the village deposits that surround the mound and from which the mound fill was drawn.

REGIONAL DISTRIBUTION OF JAKETOWN PERFORATORS. Jill H. Miller, University of Alabama at Birmingham.

Jaketown perforators are microlithic tools that are found at prehistoric sites of the Poverty Point culture in the Southeastern United States. They seem to be specific to "typical" Poverty Point sites, and are not reported in other assemblages. Although their technological function is not clear, their importance is attested by their relative abundance at some sites. This paper surveys the regional distribution of Jaketown perforators, and considers how it relates to what we know about the wide area Poverty Point trade and ceremonial network. The pattern that emerges shows that disproportionate numbers have been recovered from sites which have been labeled "regional centers." Many intermediate sized and small sites have yielded few perforators; and at some sites they are absent altogether. The distribution pattern may suggest a use related to ceremonial, trade, or other special-purpose activities at regional centers, rather than to everyday household tasks.

Abstracts

MUSCOGEE ARTIFACTS AND ZOOLOGICAL REMAINS FROM TWO CIRCA 1830 SITES IN CENTRAL ALABAMA. Terry L. McClung, Pan American Consultants, Inc., P.O. Box 40930, Tuscaloosa, Al 35404.

Recent investigations at two pre-removal (1830-36) Muscogee sites have uncovered a marked increase in the use of European ceramics. If not for Muscogee ceramics these sites would be indistinguishable from Georgian and Alabamian farmer sites. Six aboriginal ceramic vessel forms have been discerned at the Cross Keys site located in the Tallapoosa river drainage, none of which have incised decorations, yet, further north, in the Coosa river drainage, ceramic vessels from the Tin-Chaw-Way site are dominated by two distinctive incised designs. This may be an indication of political or social divisions found among Muscogee groups at that time. Faunal remains will show that Muscogee people during this pre-removal period received up to 80 percent of their meat diet from domestic sources introduced from Europe, mainly cattle and hogs. Astragali measurements indicate a slight drop in white-tailed deer weight during this period, with a 114 lbs average live weight, perhaps a result of increased hunting pressure because of the increase in human immigrant population. Bone elements were broken for their marrow and also to allow for easy insertion into cooking pots.

ARCHAEOLOGICAL INVESTIGATIONS AT CHANTILLY INN, MONTGOMERY COUNTY, ALABAMA. Shari D. Moore, Panamerican Consultants, Inc., Tuscaloosa, AL 35404.

In 1992, Panamerican Consultants, Inc. conducted a Phase I archaeological survey under contract with the Alabama Department of Transportation in connection with the relocation of Highway 110 east of Montgomery. As a result of this survey, Phase II testing and evaluation was conducted near a National-Register-eligible historic property now known as Chantilly Inn, a Colonial period plantation house. While the field work produced negative results, archival research uncovered a wealth of information concerning the property and its former occupants.

WHERE WAS COFITACHIQUI? Bill Reid, Dept. of Physical Sciences and Engineering, Jacksonville State University, Jacksonville, AL 36265.

Among the more exotic communities visited by the de Soto entrada was Cofitachiqui, ruled by a glamorous young Amerindian princess. Various locations have been suggested for it. Swanton placed it on the Savannah at Silver Bluff, near Augusta. Hudson has championed a site near Camden, SC. Much of the evidence is equivocal, but a 1670 visit to "Chufytachyqj" by Dr. Henry Woodward of South Carolina gives an azimuth and distance which favors the Swanton location.

Abstracts

MISSISSIPPIAN DUGOUT CANOES FROM ALABAMA AND MISSISSIPPI. Richard S. Fuller, Alabama Museum of Natural History, Univ. of Ala., University, AL 35487. Richard S. Fuller.

In 1989, a well-preserved dugout canoe was discovered during dredging of a bayou in northwestern Mississippi. The complete canoe was recovered intact and was transported to a secure location for preservation. Analyses of the dugout, its setting, and associated artifacts indicated a sixteenth-century date. Three additional canoes from Mississippi and Alabama have been dated to the Mississippi period, and a fourth is believed to be contemporary. Occurring as much as 350 km apart, the five dugouts constitute a distinctive type, revealing a diagnostic Mississippian style for the region.

Comic books as material culture. Kenneth W. Oswald, Dept. of Anthropology, Univ. of Ala. at B'ham, Birmingham, Al 35294.

Techniques used to analyze material culture have been adopted in ethnography to make inferences about present day people. By using those same techniques to analyze comic books, inferences can be made about the people who acquire, read, collect, and trade them. Comic book iconography is examined as a means of exploring various themes of contemporary society. Examination of a survey of comic book buyers from shops in the Birmingham/Tuscaloosa area indicates the interests of these people participating in acquiring, reading, collecting, and trading these items. This information, along with interviews conducted to examine the details of marketing, storage, and exchange of comic books as commodities, is compared and contrasted with the study of comic books as objects of material culture.

WRIGHT'S FARM SITE, 1Ca18, REVISITED. Harry O. Holstein, Department of Geography and Anthropology, Jacksonville State University, Jacksonville, AL 36265. Harry O. Holstein, Jacksonville State University, Jacksonville, AL 36265

As a result of two summer field schools conducted at the Wright's Farm Site, 1Ca18 near Alexandria, Alabama, Jacksonville State University students have uncovered a sizeable portion of Late Archaic/Woodland Aboriginal Village. Numerous storage pits have provided a wealth of dietary information indicating Woodland populations exploited heavily such food resources as walnuts, hickory, deer, turtles, and freshwater periwinkles. One late Woodland Coker Ford phase feature, Feature 54, yielded several liters of charred maize kernels. However, artifact assemblage indicates a predominance of early middle Woodland Cedar Bluff phase.

MINUTES

ALABAMA ACADEMY OF SCIENCE
SPRING EXECUTIVE COMMITTEE MEETING
TROY STATE UNIVERSITY
TROY, ALABAMA
MARCH 23, 1994

- A. Dr. Prakash Sharma, AAS President, called the Spring Executive Committee Meeting to order at 7:45 p.m. The minutes of the Fall meeting were approved as submitted. Dr. Sharma then proceeded to ask for officer and committee reports.
- B. Officers' Reports
 - 1. Board of Trustees - Dr. Barker pointed out in an informal report that five members of the Board of Trustees were present, including Samuel Barker, Joseph Thomas, James Wilkes, Elsie Spencer and Dan Holliman.
 - 2. President - Dr. Sharma reported that he:

Coordinated details of annual meeting with Dr. Destito, Chair, Local Arrangements Committee.

Finalized details of Dr. Jaeger's speech at Banquet.

Sent letter of Invitation to Dr. Jack Hawkins, Chancellor, Troy State University.

Sent congratulatory and invitation letters to Drs. Rose, C. Randall Clark, A. K. Valaer, J. DeRuiter and F. T. Noggle.

Sent Campus/Sectional Coordinators membership application forms and call for paper brochures.

Worked with Dr. Frandsen on a project of Committee on Science and Public Policy.

Made 69 new members of the academy.

Engaged in numerous telephone conversations and discussions with Committee chairs, sectional chairs and vice-chairs.

Minutes

3. President-Elect - Dr. Eugene Omasta reported that he had assisted other Academy offices as needed and had coordinated AV equipment needs for the AJAS.

4. Second Vice-President - Dr. Don Holliman submitted the following report:

During this last year I have had the opportunity to work closely with the President and Vice President of the Academy. Additionally, I have chatted with some of the other officers to get a feel for their jobs and responsibilities.

I have suggested that letters of appreciation be sent to all outgoing officers and members of the Board of Trustees expressing our gratitude for their services.

Also, I have mentioned to the Administrative Assistant of the Secretary that current telephone numbers be kept on file whenever possible. Perhaps change-of-address cards could periodically be distributed to those people who are experiencing address changes. Frequently, when someone retires from the Executive Committee or Board of Trustees we have no record of their current address or telephone number.

5. Secretary - Dr. Larry Boots reported as follows:

Secretary's Report - March 23, 1994

Membership as of March 24, 1993	661
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Membership as of March 22, 1994	739
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Membership increased 78 members from 1993 to 1994

Members dropped due to non-payment of dues	100
Individual membership (66)	
Student memberships (33)	
Sustaining individual (1)	

New Membership since January 1, 1994	69
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Trends in Membership:	<u>Members</u>
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March 1989	905
March 1990	912

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March 1991	872
April 1992	728
March 1993	661
March 1994	739

MEMBERSHIP BY SECTION

<u>Section</u>	<u>April 1992</u>	<u>March 1993</u>	<u>March 1994</u>
I. Biological Sciences	155	168	186
II. Chemistry	82	77	70
III. Geology	25	23	25
IV. Forestry, Geography Conserv., &Planning	21	28	23
V. Physics & Math	76	69	105
VI. Industry & Economics	29	23	35
VII. Science Education	27	27	32
VIII. Social Science	25	27	25
IX. Health Science	101	93	99
X. Engineering & Computer Science	44	31	50
XI. Anthropology	13	13	12
99. Industry, Politician, etc.	13	2	2
77. Libraries - Universities	26	22	23
88. Libraries - High School	50	51	51
Unknown	3	7	1

6. Treasurer - Dr. Larry Krannich submitted the following report:

Information for Calendar Year 1994:

ALL ACCOUNT BALANCES as of 3/11/94

TREASURER'S SUMMARY REPORT BY QUARTER as of 3/11/94 for the period 1/1/94 through 3/11/94

ACTIVITIES RELATIVE TO 1994 BUDGET for the period 1/1/94 through 3/11/94

Information for Calendar Year 1993:

ALL ACCOUNT BALANCES as of 12/31/94

ACTIVITIES RELATIVE TO 1993 BUDGET for the period 1/1/93 through 12/31/93

Minutes

TREASURER'S SUMMARY REPORT BY QUARTER for the period 1/1/93 through 12/21/94

Due to vigorous solicitation for dues in the Fall of 1993, we collected \$3,019 in dues more than we projected in the budget. This is evident in the \$3,499 and \$8,555 collected in the third and fourth quarter of 1993 as compared with \$695 and \$7,895 for these respective quarters in 1992. Also we have only collected \$3,015 so far this year (1994) relative to \$4,195 collected in the first quarter of 1993. Very few dues checks have been processed during the last four weeks. Although income for 1993 was less than projected by \$916.82, expenses were held down in a number of categories so that we ended the year expending \$7,399.54 less than projected. Thus, we have a net income of \$527.72 above expenses and a balanced budget for 1993.

The symposium support income indicated in income in the first quarter of 1994 is from TVA for support of the Zebra mussel symposium last spring. They paid us in February of 1994. A comparison with the first quarter of 1993 is difficult to make at this time, because expenses associated with the annual meeting, awards, and science fair are yet to be realized.

The 1994 activities appear to be keeping with our approved 1994 budget.

7. Journal Editor - no report was submitted.

8. Counselor to AJAS - Dr. B. J. Bateman reported that:

The Alabama Junior Academy of Science has a full schedule of activities planned for the annual meeting, including: the paper competition among 40 regional winners, local tours, the caucus and the election of state officers, presentation of awards, the joint banquet with the movie, and the Saturday rap session with our banquet speaker, Dr. Jaeger.

At this time, 118 students the sponsors have pre-registered for the meeting and 106 plan to attend the joint banquet.

9. Science Fair Coordinator - Dr. B. J. Bateman presented the following report:

The Science Fair Coordinator, Mary Thomaskutty, asked me to report that she would mail in her final report. All areas have not had their fairs at this time.

She also reminds the Academy that she did not request any funds this year since she had funds left over from last year. However she will need more than normal funds next year since the International Science Fair will be in Canada.

Minutes

10. Science Olympiad Coordinator - Steven Carey submitted the following:

The Alabama Science Olympiad infrastructure currently consists of six Division C (grades 9-12) and four Division B (grades 6-9) Regional Science Olympiad Tournaments. This represents an increase of one Division B regional from last year. Winning regional teams advance to the State Science Olympiad held at the University of Alabama in Birmingham.

In 1994, 98 Division C and 51 Division B teams competed in regional Science Olympiads. This level of competition involved approximately 2384 students and coaches statewide. Eighteen Division C and 12 Division B teams will compete at the State Science Olympiad at UAB. From this group, one Division B and two Division C teams will advance to the National Science Olympiad to be held at the University of Arizona, Tucson, May 20-21, 1994. This year marks the 10th Anniversary of the National Science Olympiad, so the National Science Olympiad should be a special occasion.

As Alabama Science Olympiad Director, I attended the Regional Science Olympiads at UMS-Wright Preparatory School and the University of Mobile. I also attended a meeting hosted by Alabama Power Foundation Meeting of Alabama Science Educators held in Montgomery on November 18, 1993. Later this spring, I will attend the State Science Olympiad at UAB, the National Science Olympiad, and the National Science Olympiad State Directors Meeting. It was decided last year to have an annual meeting of the State Director and Regional Coordinators take place during the annual AAS meeting. We had our first meeting last year, and will continue the tradition this year. This has improved communication between the regions and helped to standardize rules and events among the host institutions.

11. Counselor to AAAS - no report was given.

12. Section Officers:

- I. Biological Sciences - Dr. Stephen Watts reported that 35 papers and 9 posters would be presented.
- II. Chemistry - no written report was submitted.
- III. Geology - no report.
- IV. Forestry, Geography, Conservation and Planning - Dr. Priscilla Holland submitted the following:

The Forestry, Geography, Conservation, and Planning Section has 16 papers and one poster for the 1994 71st Annual Meeting. This is a decrease from the 20

Minutes

papers submitted for the 1993 70th Annual Meeting. Eleven of the sixteen papers are by students, with four being entered in the Student Research Paper Competition. One poster has been submitted for competition.

Geography dominates the section in number of papers and members as it has for the last ten years. Because of this, changing the name has been an issue for discussion in the past three business meeting. The section chair would at this time like to place before the Executive Committee a notice of intent: that the name for Section IV (Forestry, Geography, Conservation, and Planning) be changed to Geography.

V. Physics and Mathematics - Dr. William Boardman submitted this report:

There will be a total of thirteen papers and posters contributed to the 1994 meeting, including one submitted too late to be included on the printed program.

VI. Industry and Economics - Dr. Rick Lester submitted the following:

The Industry and Economics Section had a slight decrease (10%) in the number of papers to be given at the 1994 annual meeting as compared to 1993. Although there were fewer papers, there was an increase in the number of Universities represented at this year's meeting. Further, there was an increase in the student participation with seven students providing work this year.

VII. Science Education - Dr. Myra Smith presented the following report:

Throughout the 1993-94 year various deans and department heads were contacted in an attempt to increase the number of papers to be presented at the annual meeting. The Science Education section plans to have 11 papers presented at this years Annual meeting on March 25. This is an increase of one paper from the last annual meeting. A wide variety of topics are to be presented, ranging from "teaching science through children's literature" to "correlation of attitudinal responses to grades in human anatomy and physiology".

VIII. Behavioral and Social Sciences - Dr. Richard Hudiburg gave this report:

The Behavioral and Social Science section had sixteen papers submitted for the 1994 annual meeting. This represents a 100% increase over the number of papers read at the 1993 annual meeting. This increase was due in part to the increased number of student participant papers (7) and an increase in the number of participating Universities. The section especially thanks Auburn University - Montgomery and Troy State University for their participation.

IX. Health Science - Dr. Jerry Thompson reported that:

Minutes

Last year at the Alabama Academy of Science Annual meeting, 1993, we had a total of 17 papers. Thirteen were platform and four were poster presentations.

This year in the Health Science Section of the Alabama Academy of Science at Troy State University we will have a total of 34 papers for presentation. A total of twelve will be platform presentations and 22 will be poster presentations. However, we only have one student in the competition for an award. The increase in papers this year has been in the Poster session. The poster is a good way for students to present their work since they have to organize their thoughts and express them on paper for everyone to review. I ask that we please encourage both faculty and students to attend the posters sessions.

- X. Engineering and Computer Science - no report.
- XI. Anthropology - no report.
- 13. Executive Director - Dr. Leven Hazelgrove submitted the following:

Since the Fall Executive Meeting, October 22, 1993, SRI, we have been working on the following projects during the last 5 months:

- 1. Set up the Gorgas Scholarship Foundation, Inc., Science Talent Search in cooperation with the Westinghouse Scholarship Ranking Science Service, Inc. D.C. at the TSU meeting, March 26, 1994, and with the leadership of Dr. Glynn Wheeler, Sect. Treasurer and Dr. Edward Barrett, TSU.
- 2. Mailed by bulk mail nearly 900 Newsletters edited by Dr. Richetto, October 1993.
- 3. Sent development letters to 10 industrial companies and foundations with positive replies from four.
- 4. Assembled, edited and prepared for bulk mail 900 TSU Programs for TSU meeting March 23-26, 1994, with Dr. Barrett's able assistance and Ms. Amie Stoppelbein, Microbiology, UAB.
- 5. Sent hand written notes to 50 outstanding Scientist and Engineers, Mathematicians, and potential members whose "write-up" appeared in local publications. Forty New Members!!
- 6. Met with Dr. Ellen Buckner, Prof. of Nursing, UAB, 934-6799 and her local committee for the 1995 AAS dates: March 15-18, 1995, UAB.
- 7. Ordered and picked up the Gardner plaque for 1994 after the selection made by Dr. R. Kent Clark, USA, and his committee of Dr. M. Frank Rose, Auburn university.

Minutes

8. Lettered and framed 4 award certificates for four authors from Auburn University for the Carmichael awards with leadership from Dr. Velma B. Richardson, Chairperson, Tuskegee University.

9. Rewrote Recruiting Brochure and had printed 1000 copies, thanks to Dr. Gail Cassell, Chairperson and Professor of Microbiology.

10. Moved the AAS Executive Director's office to the new Bevill Biomedical Research Building, UAB, from Dr. Shoemaker's Lab after 4 years of sharing same with many thanks: New phone (205) 934-4027, FAX (205) 934-9356.

C. Committee Reports

1. Local Arrangements - Dr. Lou Destito reported that everything was in place and a good meeting was expected.
2. Finance - Dr. Samuel Barker presented the following:

Report of Committee on Budget & Finance: S. B. Barker, Chairman

Our Treasurer's Report for the complete 1993 calendar year again shows a balance (\$528) as compared to a budgeted deficit of nearly \$6,000. This is in spite of less than anticipated income during 1993; obviously, expenditures were significantly less than anticipated in the budget. Of course, if there must be a discrepancy, this is the "safest" way to go, but it may imply that the Academy is not fully living up to its responsibilities. That implication is, of course, a matter for this Executive Committee to consider if it so desires.

The only way we can effectively face this is to spend a great deal of time picking over the fiscal details, and I do not want to try your patience. For one thing, as the Treasurer and I have emphasized before, the variabilities in Academy Income and Expenditures from quarter to quarter in any given year are so great the entire year is the only meaningful time basis. For example, the featured Zebra Mussel Symposium cost \$1,973, for which \$1,000 had been budgeted, but no income was received until the first quarter of 1994, when the entire cost was recovered.

As a discrepancy in the opposite direction, the Mason Fellowship Fund received only \$702 income in 1993, compared to the anticipated \$900. However, there were no expenditures for the Mason Fellowship in 1993, despite a budget allocation of \$2,000. The Award Chairman was distressed that only \$1,000 was put into the 1994 Proposed Budget, but without clearly anticipated expenditures, how can the Treasurer react?

Minutes

The 1994 Academy Budget, proposed and accepted at the Fall Executive Committee meeting, again shows a considerable deficit of \$3,451 (from Income of \$28,500 and Expenses of \$31,951. From the Treasurer's Summary Report for a little less than the First Quarter of 1994, Income is down, but Expenses are very low. I think we must understand the vagaries of quarterly activities, with our largest expenditures coming with this very Annual Meeting, and not be overcome by a temporary balance of nearly \$5,000.

3. Membership - no formal report given:
4. Research - Dr. Tom Jandebeur presented the following report:

Student Travel Award: The Committee on Research received 29 requests for travel awards. All the students are presenting papers/posters; 24 of the students are entered in the Student Research Award competition. Using a \$15.00 minimum (equivalent to the student registration fee for the meeting), considering also travel distance from the student's home institution to Troy State University, and their status as a competitor in the Student Research Award competition, the amount budgeted for travel awards (\$600.00) was allocated as follows:

Number of Awards	Affiliation	Distance (One-way)	Award \$
1 (non-competitor)	TU	57	15
3 (non-competitors)	JSU	178	20
4	AU	79	15
15	UAB	136	20
1	BSU	136	20
1	UA	150	20
1	SHC	173	25
2	UNA	255	30
1 (non-competitors)	UAH	237	25
29			585

STUDENT RESEARCH AWARD: Thirty-three papers and 2 posters are entered in the Student Research Award competition. The following summary indicates the competitors by Section and their institutional affiliation.

PAPERS 33

Minutes

Section I. Biological Sciences (15)

1-AU
1-SHC
13-UAB

Section II. Chemistry (6)

1-BSU
1-TSU
4-UAB

Section III. Geology (1)

1-UA

Section IV. Forestry, Geography, Conservation & Planning (4)

2-UNA
1-SU
1-?

Section IX. Health Sciences (1)

1-UAB

Section X. Engineering & Computer Science (6)

2-AU
4-UAB

POSTERS - 2

Section IV. Forestry, Geography, Conservation & Planning (1)

1-UNA

Section X. Engineering & Computer Science (1)

1-AU

STUDENT RESEARCH GRANT: As reflected below, the Committee received 12 applications for research grants from students enrolled at 4 institutions, and representing 3 Sections of the Academy.

Minutes

Section I. Biological Sciences (7)

5-UAB

1-JSU

1-AU

Section IV. Forestry, Geography, Conservatin & Planning (1)

1-UNA

Section X. Engineering & Computer Science (4)

4-UAB

Decisions regarding allocation of the amount budgeted for research grants (\$2500.00) will be finalized Thursday evening, March 24. The maximum award is \$250.00. Grant recipients will be announced at the Business Meeting, Friday, March 25.

5. Long-range planning - no report.
6. Auditing - Sr. Academy - no report.
7. Auditing - Jr. Academy - Drs. Barbara Reynolds and Fred Viohl reported:

We have examined the books provided by the Alabama Junior Academy of Science Treasurer, Dr. B. J. Bateman. We are satisfied ourselves that the receipts and expenditures, as presented to us, are correct and that all expenditures are legitimate expenses.

The net worth as of June 30, 1993 is \$3142.90.

8. Editorial Board and Associate Journal Editors - Dr. Wit submitted this report:

The following thirteen institutions contributed a total of \$4,050 to the Academy to help defray publication costs of the *Journal*:

Tennessee Valley Authority
University of Montevallo
Troy State University
Birmingham-Southern College
Samford University
University of North Alabama

Minutes

University of Alabama at Birmingham
Tuskegee University
University of Alabama
Jacksonville State University
University of South Alabama
Auburn University at Montgomery
Mobile College

These funds are in addition to the \$4,308 "contribution" of Auburn University. I continue to search for additional Benefactors of the *Journal*.

9. Place and Date of Meeting - Dr. David Nelson reported as follows:

The following sites have been previously approved by the Executive Committee of the Alabama Academy of Science:

1995 U.A. Birmingham
1996 Tuskegee University

The committee on Place and Date of Meeting recommends that we approach Auburn University at Montgomery about hosting the meeting of the academy in 1997. We met at AUM in 1986. If we cannot meet at AUM, we should consider USA (met there in 1984) or UNA (met there in 1987). The contact person for AUM is Dr. Marion Michael (244-3600).

Committee on Place and Date of Meeting

David H. Nelson (1997), Department of Biology, University of South Alabama, Mobile, Alabama 36688, 460-6331.

James E. Brown (1995), Department of Horticulture, Auburn University, Auburn, Alabama 36849, 844-4862.

Richard Modlin (1997), Department of Biological Sciences, University of Alabama in Huntsville, Huntsville, Alabama 35899, 895-6360.

Ms. Janice Gilliland (1994), Department of Community Development, 2705 18th Avenue, Apt. G, Northport, Alabama 35476.

Lawrence J. Hanks (1996), Department of Political Science.

10. Newsletter - no report.

11. Public Relations - Dr. Ellen Buckner reported that:

Minutes

The Publicity and Public Relations Committee has not met since the fall Executive Committee meeting. Press releases for the 1994 meeting and Carmichael and Gardner Award recipients were sent to state wide academic and general media. The committee is considering drafting a manuscript on Carmichael Award winners for publication in the *Journal*.

12. Archives - Dr. Curt Peterson submitted the following:

There have been no new additions to the Academy's archival holdings since my report to the Executive Committee of 15 October 1993.

As a follow up to the Fall quarter, 1993 report, I received a listing of the living past presidents of the Academy from Dr. Hazelgrove's office. I am currently preparing a letter to send to these individuals requesting information from them for inclusion in the archival holdings. This information in the form of a curriculum vitae or a reference to a bibliographic listing will be assembled in a file on past presidents. I continue to get request for such information. I encourage all past presidents who have access to this report (and who have not already done so) to forward their CVs to me.

I continue to encourage all members of the Academy, to consider donating their Academy records to the Archives. I will be pleased to assume responsibility for transferring the records to the Archives. Please contact me at the Department of Botany and Microbiology, Auburn University, AL 36849-5407, Telephone (205) 844-1632, FAX - (205) 844-1645.

13. Science and Public Policy - Dr. John Frandsen.

The committee held its fall meeting November 13, at Auburn University, and reached agreement that it should focus its concern this year on issues relating to science education in the public schools. The reasons for this decision were that the Course of Study for Science Committee and Textbook Selection Committee would be appointed by the Governor and the State Board of Education in 1994, and, in addition, educational reform would be considered by the Legislature.

Dr. Frandsen's report included a detailed description of his committee's activities since October, a copy of which is available from the Secretary upon request.

14. Gardner Award - Dr. R. Kent Clark sent the following:

This year Gardner Award Committee received some excellent nominations for the award. The winner was chosen by a unanimous vote of the committee and the Gardner Award will be presented at the banquet on Friday.

15. Carmichael Award - Dr. Velma Richardson reported that:

Minutes

The members of the Emmett B. Charmichael Award Committee selected C. Randall Clark, A. K. Valaer, and J. DeRuiter (Department of Pharmacal Sciences, Auburn University) and F. T. Noggle (Department of Forensic Sciences, Auburn University) as the 1994 recipients of the Emmett B. Carmichael Award for their article, "Synthesis, stability and analytical profiles of 3,4-methylenedioxyamphetamines: Derivatives of "Ecstasy" (MDMA)" This article appeared in the January issue (Issue No. 1) of the *Journal*.

According to the By-Laws of the Academy, recipients of the Carmichael Award receive a suitably executed plaque and a \$250 prize at the Annual Joint Banquet. In this case, since there are multiple authors, the Award will carry the names of the three recipients, and there will be an equitable distribution of the monetary prize.

It should be noted that there was an increase in the number of papers submitted to the *Journal* and that most of the highest quality. Therefore, congratulations should be extended to everyone who submitted manuscripts to the *Journal*.

16. Resolution - Dr. Linda Reed reported that the usual resolutions would be given at the Banquet on Friday. Additional, deceased members of the Academy were recognized.
17. Nominating Committee - Dr. Dan Holliman.

A slate of Officers will be submitted for the following positions. These nominations will be made at the business meeting Friday, March 25, 1994:

President	Dr. Eugene Omasta
1st Vice President	Dr. Dan Holliman
2nd Vice President	Dr. Tom Jandebeur
Secretary	Dr. Larry Boots
Associate Counselor to the Junior Academy of Science	Betty Bigham
Coordinator of State Science Olympiad	Mr. Steven Carey
Counselor of the AAAS	Dr. Adrienne Ludwick
Four Members of the Board of Trustees	Dr. Wayne Finley Dr. Prakesh Sharma Dr. Walter Wilburn Dr. Ken Marion

Chairs and Vice Chairs for the following
committees:

Chemistry

Minutes

Geology	
Physics and Mathematics	Dr. O. M. Essenwanger - Chair Dr. John Young (V. Chair)
Science Education	Dr. Tom Bilbo - Chair Dr. Adriel Johnson (V. Chair)
Social Sciences	Dr. Gerald Burns - Chair Dr. Karen Taylor - V. Chair
Health Sciences	
Research Committee	Dr. Richard Hudiburg

18. Mason Scholarship - Dr. Stan Jones reported:

Although the deadline for applications was March 18, only 1 application for the Mason Scholarship has been received; a second is anticipated. This year the award was listed as \$1000, in contrast to the \$2000 of past years, but I do not believe this is the only reason for the drop in applications.

This is an important activity of the AAS, and it is my recommendation that next year's committee explore better means of publicizing this award. They might also consider relaxing the allowable uses of the scholarship. For instance, they might decide to make it an outright award, rather than tying it to school expenses as is now the case. A good student will be likely to get an assistantship which covers tuition, and may not be using university housing. This would seem to leave only books as allowable expenses. If our intent is to attract and reward good students in science education, perhaps a more lucrative-sounding award would be better.

D. New Business

A motion was entertained to change the name of Section IV to "Geography". It was tabled until the Fall meeting.

There was a discussion concerning the type of student, i.e. graduate, undergraduate, etc., that should be eligible to compete in the research paper competition. This was referred to the Research Committee.

Notes

Notes

Notes

INSTRUCTIONS TO AUTHORS

Editorial Policy: Publication of the *Journal of the Alabama Academy of Science* is restricted to members. Membership application forms can be obtained from Dr. Larry R. Boots, Department of Obstetrics & Gynecology, University of Alabama, Birmingham, AL 35294. Subject matter should address original research in one of the discipline sections of the Academy: Biological Sciences; Chemistry; Geology; Forestry, Geography, Conservation, and Planning; Physics and Mathematics; Industry and Economics; Science Education; Social Sciences; Health Sciences; Engineering and Computer Science; and Anthropology. Timely review articles of exceptional quality and general readership interest will also be considered. Invited articles dealing with Science Activities in Alabama are occasionally published. Book reviews of Alabama authors are also solicited. Submission of an article for publication in the *Journal* implies that it has not been published previously and that it is not currently being considered for publication elsewhere.

Submission: Each manuscript will receive at least two simultaneous peer reviews. Include in your letter of transmittal the names, addresses, and telephone numbers of at least four qualified referees. Do not include names of individuals from your present institution.

Manuscripts: Consult recent issues of the *Journal* for format. Double-space manuscripts throughout, allowing 1-inch margins. Number all pages. Submit the original and two copies to the Editor. Papers which are unreasonably long and verbose, such as uncut theses, will be returned. The title page should contain the author's name, affiliation, and address, including zip code. An abstract not exceeding 200 words will be published if the author so desires. Use headings and subdivisions where necessary for clarity. Common headings are: Introduction (including a literature review), Procedures (or Materials and Methods), Results, Discussion, and Literature Cited. Other formats may be more appropriate for certain subject matter areas. Headings should be in all-caps and centered on the typed page; sub-headings should be italicized (underlined) and placed at the margin. Avoid excessive use of footnotes. Do not use the number 1 for footnotes; begin with 2. Skip additional footnote numbers if one or more authors must have their present address footnoted.

Illustrations: Submit original inked drawings (graphs and diagrams) or clear black and white glossy photographs. Width must not exceed 15 cm and height must not exceed 20 cm. Illustrations not conforming to these dimensions will be returned to the author. Use lettering that will still be legible after a 30% reduction. Designate all illustrations as figures, number consecutively, and cite all figures in the text. Type figure captions on a separate sheet of paper. Send two extra sets of illustrations; xeroxed photographs are satisfactory for review purposes.

Tables: Place each table on a separate sheet. Place a table title directly above each table. Number tables consecutively. Use symbols or letters, not numerals, for table footnotes. Cite all tables in the text.

Literature Cited: Only references cited in the text should be listed under Literature Cited. Do not group references according to source (books, periodicals, newspapers, etc.). List in alphabetical order of senior author names. Cite references in the text by number or by author-date.

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NO. 3

COVER PHOTOGRAPH: The gray squirrel (*Sciurus carolinensis*) is a common resident of deciduous and mixed pine-hardwood forests of Alabama. It is a popular game species within the state, and due to its diurnal behavior, is also one of the state's more observable species of small mammals. This species has been studied by personnel of the Alabama Cooperative Fish and Wildlife Research Unit at Auburn university. Work by them at the Solon Dixon Forestry Education Center in south Alabama has shown differences in habitat use and relative abundances of gray squirrels among forest types. Male squirrels have larger home ranges than those of females, and home range appears to be larger in even-aged pine than in other forest types. The size of home ranges of squirrels in pine habitats may be influenced by the presence of riparian areas. Such areas improve the overall value of pine habitats for gray squirrels. Photograph by Thomas E. Nupp.

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JULY 1994

NO. 3

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HOME RANGES OF GRAY SQUIRRELS IN SOUTHERN ALABAMA¹

Richard A. Fischer and Nicholas R. Holler

*Alabama Cooperative Fish and Wildlife Research Unit,
Auburn University, AL 36849-5414, and National Biological
Survey, Alabama Cooperative Fish and Wildlife
Research Unit, Auburn University, AL 36849-5414*

ABSTRACT

We used radiotelemetry to determine mean seasonal home ranges of gray squirrels (*Sciurus carolinensis*) in three forest types (even-aged pine [*Pinus* spp.], pine-hardwood, hardwood) in southern Alabama from 1987-1988. Home ranges of males (5.44 ± 1.00 [x±S.E.] ha; $n = 34$) were greater ($P = 0.0001$) than those of females (1.28 ± 0.16 ha; $n = 32$). No differences in size of home range of males were observed among habitat types ($P = 0.33$). Home ranges of females in even-aged pine were larger, although not significantly ($P = 0.13$), than those in hardwood or pine-hardwood. No correlations were found between seasonal home range and estimates of relative abundance in any of the forest types.

INTRODUCTION

Dispersal, movements, and size of home ranges of gray squirrels (*Sciurus carolinensis*) have been monitored by visual observation (Pack 1966), livetrapping (Cordes and Barkalow 1972, Donohoe and Beal 1972, Doebel and McGinnes 1974), and radiotelemetry (Flyger 1960, Doebel and McGinnes 1974, Hotton 1978). However, radiotelemetry generates the most reliable information for determination of home range (Doebel and McGinnes 1974). Differences in size of home range among studies are apparent. For example, gray squirrels occupied mean ranges of 0.49 ha in Virginia (Doebel and McGinnes 1974), 0.57 ha in Maryland (Flyger 1960), 1.09 ha in North Carolina (Cordes and Barkalow 1972), 4.78 ha in Ohio (Donohoe and Beal 1972), and 3.3 ha in Alabama (Hotton 1978). Cordes and Barkalow (1972) suggested differences in home range among studies can be related to habitat characteristics and population densities, but season, sex, and age composition, food availability, and technique are also important (Flyger and Gates 1982). Comparisons of home range size among studies are therefore difficult to make (Flyger and Gates 1982).

¹Manuscript received 25 April 1994; accepted 6 June 1994.

Fischer and Holler (1991) reported differences in habitat use and relative abundance of gray squirrels among forest types in southern Alabama. Size of home ranges, as influenced by squirrel densities, may also differ among these forest types. Don (1983) hypothesized an inverse relationship between size of home range and population density. An empirical test of these hypotheses can be made by comparing home ranges with estimates of population density within the same forest area and among different forest types over time. Our objective was to describe seasonal home ranges of individual squirrels within three forest types in southern Alabama, and specifically test the hypotheses that (1) home range size is independent of forest type, and (2) there is no correlation between size of home range and density of squirrels within forest types.

MATERIALS AND METHODS

Description of study area-- Our 2,165-ha study area was at the Solon Dixon Forestry Education Center (DFC), School of Forestry, Auburn University. The DFC was located in Covington and Escambia counties, southern Alabama, within the Lower Coastal Plain physiographic region. The forests consisted of upland and bottomland hardwood [HW] (23%), upland areas of pine-hardwood [PH] including several sand hills (40%), numerous even-aged pine [EAP] plantations (33%), and regenerating cutover areas (4%) (E. E. Johnson, DFC, pers. commun.).

Bottomland HW overstory was dominated by laurel oak (*Quercus laurifolia*), swamp chestnut oak (*Q. michauxii*), and water oak (*Q. nigra*), interspersed with a variety of other HW species including American beech (*Fagus grandifolia*), sweetgum (*Liquidambar styraciflua*), hickory (*Carya spp.*), maple (*Acer spp.*), ash (*Fraxinus spp.*), elm (*Ulmus spp.*), and spruce pine (*P. glabra*). Upland HW forests were dominated by laurel oak and white oak (*Q. alba*), ash, elm, sweetgum, maple, and eastern red cedar (*Juniperus virginiana*). The upland PH areas were characterized by an overstory and midstory of longleaf pine (*P. palustris*), loblolly pine (*P. taeda*), southern red oak (*Q. falcata*), laurel oak, and post oak (*Q. stellata*). Even-aged pine stands were composed mainly of loblolly and longleaf pines, but slash pine (*P. elliotti*) and shortleaf pine (*P. echinata*) species were also present.

The DFC forests were intensively managed (e.g., prescribed fire, selective-cutting, herbicide application), although all study sites within the study area (see below) were unaltered during the study. Riparian areas, defined in our study as narrow (<100 m wide) HW stringers that lined ephemeral streams, occurred within many EAP and PH stands and usually extended the length of the stand. See Fischer and Holler (1991) for a detailed description of the study area.

Capturing--We captured gray squirrels in nine sites within three forest types (three each of EAP, PA, HW; Table 1; Figure 1) on the study area using 50-station trapping grids with line intersections at 60 m. Trapping grids were of various shapes and were

Gray Squirrels

situated to provide the maximum distance from adjacent forest types. Two no. 203 Tomahawk double-door livetraps were placed at each grid intersection point. From mark/recapture data, relative abundance was compared among forest types (Fischer and Holler 1991). In the winter of 1987, we randomly selected one area of each forest type for radiotelemetry. We anesthetized squirrels with Metofane® (Methoxyflurane, Pitman-Moore, Inc., Washington Crossing, NJ, 08560)(Barry 1972) and attached neck-collar radiotransmitters to each. Squirrels in two additional areas (PH and HW) received transmitters in summer and autumn 1987. A small number of captures within EAP habitat precluded an additional pine area. We attached additional transmitters to squirrels in all areas as necessary to replace those lost when squirrels died or transmitters failed.

Table 1. Size and Age of Study Sites at the Solon Dixon Forestry Education Center, Covington and Escambia Counties, Alabama.

Stand	Size (ha)	Age (yrs.) ^a
EAP1	20.0	40
EAP2	21.2	50
EAP3	20.6	45
PH1	21.8	50
PH2	21.2	45
PH3	21.8	50
HW1	21.2	65+
HW2	17.6	65+
HW3	18.8	65+

^aAges are approximate and represent means of dominant and co-dominant trees.

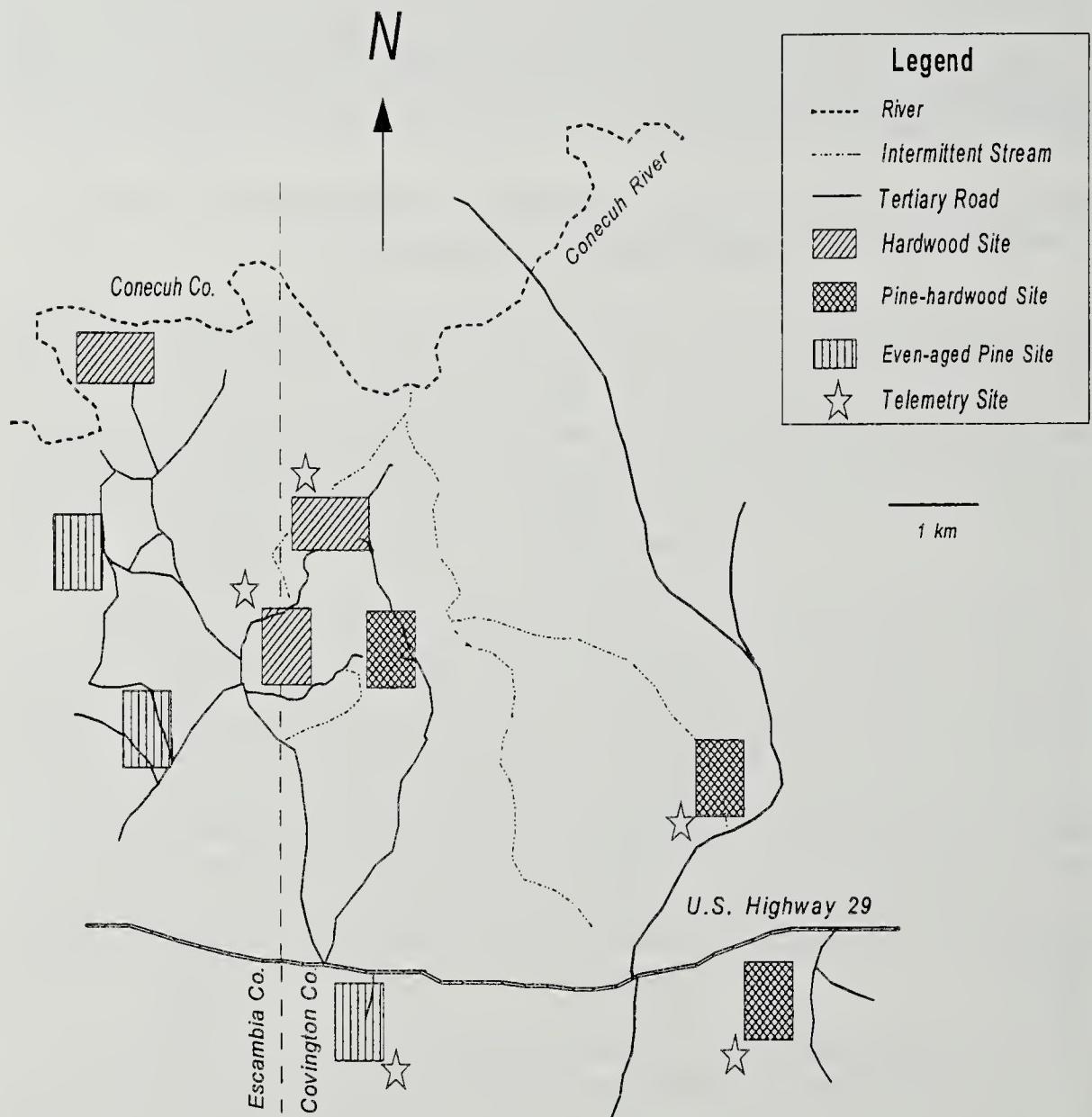


Figure 1. Gray Squirrel study site locations at the Solon Dixon Forestry Education Center, Covington and Escambia Counties, Alabama.

Gray Squirrel

Telemetry.--We defined seasons *a priori* as autumn (Oct-Dec), winter (Jan-Mar), spring (Apr-Jun), and summer (Jul-Sep). Squirrels were monitored ≥ 1 day/week during winter and autumn 1987, and spring and summer 1988 with a portable handheld receiver and 3-element yagi antenna. During spring and summer 1987, and winter 1988, all squirrels were monitored for ≥ 2 days/month. We located each squirrel within one of the forest types, twice in the early morning (0600-0900h) when activity was greatest, and again in the late afternoon or evening (1700-2000h). This procedure was followed for the remaining areas on consecutive days. When we made visual contact or determined the tree cavity or nest containing a squirrel, locations were recorded as the bearing and distance from the nearest grid-intersection point. When squirrels were in dense vegetation or when we believed that approaching squirrels would influence movement, we determined locations by the intersection of bearings from the two nearest trapping stations. Although we did not estimate location error, squirrels usually were ≤ 60 m away using the second method.

We plotted all locations on aerial photographs (1 cm = 52.8 m) and assigned x and y coordinates. We used TELE (Coleman and Jones 1986) to calculate convex-polygon home ranges (Mohr 1947) for each individual by season (seasonal home range). Determinations of individual home ranges was based on ≥ 12 seasonal locations. We used a nonparametric ANOVA (Conover and Iman 1981) on ranks of estimates of size of home range to estimate differences in seasonal home range among forest types and seasons, and between sexes ($P < 0.05$). We converted seasonal data on relative abundance (minimum number known alive [MNA]) to density for each site by dividing MNA by area of each site. We tested for a relationship between size of home range and density using a Spearman rank correlation (Zar 1984).

RESULTS AND DISCUSSION

Radio transmitters were attached to 6 squirrels in EAP (4 males [M], 2 females [F]), 11 squirrels in PH (5M, 6F), and 13 squirrels in HW (5M, 8F). Telemetry locations ($n = 1,210$) were obtained for 66-564 days $\bar{x} = 206$ days) for 30 individual squirrels. Seasonal home ranges of 14 males (5.44 ± 1.00 ha [$\bar{x} \pm$ S.E.]; $n = 34$) were greater ($F = 23.5$, $P = 0.001$) than those of 16 females ($\bar{x} = 1.28 \pm 0.16$; $n = 32$ (Table 2). No differences in size of home range were observed among habitat types for males ($F = 1.15$, $P = 0.33$, $n = 34$) or females ($F = 2.20$, $P = 0.13$, $n = 32$). Power of the test to detect a difference in size of home range among habitat types could not be calculated for the nonparametric ANOVA. However, our sample sizes probably yielded low statistical power. When sexes were pooled, seasonal home ranges differed among forest types ($P = 0.0001$), with squirrels in EAP habitat having larger home ranges than those in HW or PH forests. Home ranges of males were smaller in winter than in other seasons except summer ($F = 3.49$, $P = 0.035$), but females showed no seasonal differences in size of home range ($F = 0.37$, $P = 0.77$) (for detailed figures of seasonal home ranges of individual squirrels, see Fischer [1989]).

Minimum convex polygon home ranges in our study may have underestimated home range sizes because this method is highly sensitive to sample size (Worton, 1987). However, our data on size of home range in Alabama concurred with other studies that showed males having larger home ranges than females (Taylor et al. 1971, Cordes and Barkalow 1972, Don 1983), and this may be related to nestling care by females that may raise 2 litters/year (Colin 1957). We found insignificant correlations between estimates of density and seasonal home range size of male ($r^2 = -0.07$, $P = 0.73$, $n = 28$) and female ($r^2 = -0.06$, $P = 0.75$, $n = 27$) squirrels in Alabama. In addition, no correlations were significant when sexes were analyzed within forest types. The results of our analysis by sex and forest type in Alabama do not support Don's (1983) hypothesis that size of home range is correlated with density of squirrels.

The distribution of cover types within forests may affect size of home ranges of individual squirrels. Hardwood forests were relatively homogeneous in structure. Seasonal home ranges for squirrels in HW habitat were larger, though not significantly, than those in PH habitat, and this was influenced by the relatively large home ranges of males (Table 2). Only one squirrel that was radiomarked within a HW stand ranged outside of that stand, and these movements were recorded during peak breeding seasons in Alabama (Colin 1957). All EAP and PH sites had riparian areas, either within or bordering the stand. These riparian areas may confound interpretation of home range sizes by masking larger home ranges of squirrels in EAP and PH without riparian areas. For example, the smallest seasonal home ranges were in PH habitat, where preferential use of riparian areas (Fischer and Holler 1991) appeared to decrease movement. Squirrels may not have needed to forage far from riparian areas to obtain abundant foods. The largest seasonal home ranges were in EAP habitat, primarily as a result of the large home range of one male that frequently ranged widely to use riparian areas surrounding the pine stand. Riparian areas are less abundant in EAP forests, possibly making larger movements necessary to meet food or cover requirements. Thus, we hypothesize that size of home range of gray squirrels that inhabit EAP and PH is influenced by the abundance and distribution of riparian areas throughout these stands.

Table 2. Mean size \pm S. E. (n) of home ranges (ha) of gray squirrels in three habitat types at the Solon Dixon Forestry Education Center, Covington and Escambia counties, Alabama, 1987-1988.

Sex	Hardwood	Mixed-pine hardwood	Pine
Male	5.36 \pm 1.19 (22)	2.72 \pm 0.53 (6)	8.43 \pm 3.77 (6)
Female	1.29 \pm 0.24 (16)	1.00 \pm 0.14 (13)	2.45 \pm 0.74 (3)

Gray Squirrel

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LITERATURE CITED

- Barry, W. J. 1972. Methoxyflurane: an anesthetic for field and laboratory use on squirrels. *J. Wildl. Manage.* 36:992-993.
- Coleman, J. S. and A. B. Jones, III. 1986. User's guide to TELEM: computer analysis system for radiotelemetry data. Dept. of Fisheries and Wildlife, Virginia Polytechnic Institute and State University, Blacksburg. 46 p.
- Colin, W. F. 1957. Alabama Squirrel Investigations. Ala. Dep. Conserv. and Nat. Resour. Montgomery.
- Conover, W. J. and R. L. Iman. 1981. Rank transformations as a bridge between parametric and nonparametric statistics. *Amer. Stat.* 35:124-129.
- Cordes, C. L. and F. S. Barkalow. 1972. Home range and dispersal patterns in a North Carolina gray squirrel population. *Proc. Southeast Assoc. Game and Fish Comm.* 26:124-134.
- Doebel, J. H. and B. S. McGinnes. 1974. Home range and activity of a gray squirrel population. *J. Wildl. Manage.* 38:860-867.
- Don, B. A. C. 1983. Home range characteristics and correlates in tree squirrels. *Mammal Rev.* 13:123-132.
- Donohoe, R. W. and R. O. Beal. 1972. Squirrel behavior determined by radiotelemetry. *Ohio Dept. Nat. Resour. Fish Wildl. Rep.* 2. 20 p.

Fischer and Holler

- Fischer, R. A. 1989. Habitat use and population densities of gray squirrels in south Alabama. M. S. Thesis, Auburn Univ., AL. 135 p.
- Fischer, R. A. and N. R. Holler. 1991. Habitat use and relative abundance of gray squirrels in southern Alabama. J. Wildl. Manage. 55:52-58.
- Flyger, V. F. 1960. Movements and home range of the gray squirrel, *Sciurus carolinensis* in two Maryland woodlots. Ecology 41:365-369.
____ and J. E. Gates. 1982. Fox and gray squirrels. Pages 209-229 In J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America. Johns Hopkins Univ. Press, Baltimore, Maryland. 1477 p.
- Hotton, L. D. 1978. Minimum home ranges and movements of gray squirrels in response to sawtimber cutting in Chambers County, Alabama. M. S. Thesis, Auburn Univ., AL. 51 p.
- Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Midl. Nat. 37:223-249.
- Pack, J. C. 1966. Influence of the social hierarchy on gray squirrel behavior. M. S. Thesis. Virginia Polytech. Inst., Blacksburg. 61 p.
- Taylor, K. D., M. Shorten, H. G. Lloyd and F. A. Courtier. 1971. Movements of gray squirrels as revealed by trapping. J. Appl. Ecol. 8:123-146.
- Worton, B. J. 1987. A review of models of home range for animal movement. Ecol. Modelling 38:277-298.
- Zar, J. H. 1984. Biostatistical Analysis. 2nd ed. Prentice-Hall, Englewood Cliffs, NJ.

THE PITFALL TRAP: A REVIEW OF TYPES AND THEIR USES FOR INVERTEBRATE COLLECTION¹

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ABSTRACT

The pitfall trap is an effective sampling device, especially for the capture of cursorial invertebrates. Although the trap itself may be simple in design, modifications have led to the development of complex designs. Trap-and-guard, ramp, battery-operated, and barrier pitfalls exemplify this complexity and may also be used in conjunction with terrestrial drift fences. The collecting time interval, the location of the trap, and the conditions at the sampling site can affect the composition of invertebrate collections. Preservatives and attractants may be present or absent from the trap, depending on the purpose of the study and the desired species. The lack of consistency and the considerable diversity in trap types makes comparisons between different studies difficult.

INTRODUCTION

The pitfall trap may have been first designed in nature among animals by members of the insect family Myrmeleontidae (ant lions). Artificial pitfall traps have been developed as an effective collecting device for a variety of organisms but are most often used for the capture of cursorial invertebrates. These traps come in a variety of types and are typically buried so that the rim is flush with the ground. Invertebrates crawling or running along the ground may fall into, or purposefully enter, such devices. Improved designs help to prevent escape, while attractants serve to encourage some invertebrates to enter these underground sanctuaries. The use of numerous traps helps to ensure a more representative sample from an area.

The primary advantage of pitfall trapping is that this is an efficient, convenient, relatively inexpensive method to continually sample an area. Once placed, these traps operate 24 hours a day for as long as desired; this allows, for example, the capture of nocturnal species which otherwise might be difficult to collect.

Pitfall traps do not seem to be used by many American biologists, especially in the Southeastern United States. Many of the published articles that we reviewed

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herein involving such traps came from Canada, Europe, and the Scandinavian countries. Therefore, this article will summarize pitfall trap variations and uses so that the technique may be better understood and utilized.

PITFALL TRAP TYPES AND MODIFICATIONS

Pitfall traps may vary in design so as to promote the capture of a particular species as well as of a variety of invertebrate species in a designated location. Modifications to the design of the pitfall trap depend on several factors, including the purpose of the study, the invertebrates to be captured, and the environment. These modifications have yielded an extensive array of trap designs; consequently, the size and shape of pitfall traps are limited only by the user's imagination.

The most common type of pitfall trap consists of plastic containers, which may range from a small plastic cup (Morrill, 1976; Klostermeyer et. al., 1981; Richardson, 1992) to a large 3.8-L container (Corey and Taylor, 1987). In one study, a plastic jar was used for invertebrate collection; the jar was placed in a plastic flowerpot (10.5-cm diameter) so as to minimize trap disturbance (Lyngby and Nielsen, 1980). Moreover, the depth and the diameter of the container may vary according to the invertebrates to be studied or to the preference of the trap's creator.

A variety of other containers may be substituted for plastic pitfalls. The use of glass jam jars has been reported in the capture of spiders (Jocque, 1981), 250-mL glass beakers in the collection of earwigs (Strandberg and Tucker, 1974; Strandberg, 1981), vials (4 x 10 cm) for the collection of beetles (Conn and DeMoss, 1984), and test tubes (18 x 150 mm) for the collection of ants and other arthropods (Whelan et. al., 1980; Samways, 1981). Moreover, pitfall traps have been made from tin cans (Wharton and Seely, 1982) and milk cartons (Ostaff and Freitag, 1973). Barney (1980) suggested a pitfall trap composed of galvanized metal guttering, which was cut into 1-m lengths and fitted with end caps. Luff (1975) thought gutter traps useful for determining direction of movement when they are positioned at various angles. Also, in comparing the efficiency of various trap materials, Luff found that trapping efficiency was best for glass, followed by plastic, then metal (tin). It was thought that this was primarily related to smoothness of the inside trap walls, which may have affected "capture efficiency," "retaining efficiency," or both.

The primary collecting container may be used alone or an outer liner may be present. Morrill (1976) used a combination of plastic Solo cups; a 16-oz cup was used as the outer liner, and a 3.5-oz cup was the collecting container. Pitfall traps in one study of spiders consisted of a funnel (9.0 x 7.0 cm) inserted into a plastic cup (9.0 x 12 cm); a smaller plastic cup (7.0 x 4.5 cm) served as the inner collecting device (Mangan and Byers, 1989). In studying the ground activity of spiders and harvestmen, Oppenheimer and Tikader (1976) modified pitfall traps of 23.5-cm diameter by placing a cup filled with sand in the center of the trap; this created a space of 2.5 cm

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between the sides of the trap and the cup, thereby allowing the entrance of invertebrates into this space. In addition, PVC sleeves have been used by Majer (1978) and Koch and Majer (1980) in their study of invertebrates; Pyrex test tubes were placed within PVC sleeves in order to reduce soil and litter disturbance when test tubes were removed during collection. The test tubes used in Samways' (1981, 1983) studies of ants also were enclosed in plastic sleeves. A study of cursorial spiders by Bultman et. al. (1982) involved polypropylene cups inserted into metal sleeves. Corey and Taylor (1987) studied scorpions, pseudoscorpions, and opilionids with pitfall traps in which a 19.0-L bucket served as the outer liner; holes in the bottom of the bucket reduced the accumulation of precipitation in the trap, and a 3.8-L plastic jar was placed within the bucket as the collecting device. A plywood sheet with a hole in the middle to fit over the jar mouth covered the bucket.

Clark and Blom (1992) suggested a pitfall trap design consisting of a plastic or metal container inserted into a 1.36-kg coffee can, which was buried level with the ground and contained holes in the bottom for the drainage of precipitation. The plastic lid of the coffee can prevented the entry of debris into the trap during installation and nonsampling periods. The upper portion of a 3.8-L plastic jug served as a funnel to direct invertebrates into the plastic or metal collecting device. Morrill (1976) suggested a funnel for plastic pitfalls which could be easily created by cutting the bottom of a "Solo Cozy Cup" coffee liner. The addition of funnels to the trap design can inhibit the escape of invertebrates following capture. One type of pitfall trap is commercially available from Carolina Biological Supply Company; a large cup serves as the outer liner while a smaller cup serves to collect specimens. A removable funnel is included.

The accumulation of precipitation or debris within the trap may be reduced with the use of covers. Metal sheet covers have been used in studies of opilionids (Hippa, 1975) and spiders (Hippa and Mannila, 1975). Tin plates were placed above the traps in a study of carabid beetles (Niemela et. al., 1989). In studies of carabids and arthropods, covers consisting of aluminum pie plates were used (Ostaff and Freitag, 1973; Olynyk and Freitag, 1977; Kharboutli and Mack, 1991). Morrill (1976) suggested metal or plywood covers, which were supported on wooden legs. Plastic frisbees were placed 10 cm above pitfall traps in one study of *Sitona hispidulus* (Leibee et. al., 1981). Plastic Petri plates, supported by twigs, have been used during studies of landhoppers (Richardson, 1992). In a study of carabids, Liebherr and Mahar (1979) used masonite covers (20-cm area) supported by large nails. Halmonite plates were used by Hauge and Refseth (1979) in their study of spider fauna, while Mangan and Byers (1989) selected asphalt shingles which were covered with aluminum foil for their study of spiders. A combined study of carabids and spiders (Freitag et. al., 1969) incorporated the use of a wire screen (1.5-cm mesh) as well as an aluminum roof; the wire screen prevented the capture of small vertebrates, while the aluminum roof reduced the accumulation of precipitation within the trap. "Transparent covers" (Jagers op Akkerhuis and van der Voet, 1992) and "rain shields" (Trumbo, 1990) have also been used.

Barratt and Campbell (1982) developed a trap-and-guard modification for the pitfall traps used in their study of the striped chafer, *Odontria striata*. A livestock guard was supported above the plastic trap by 12-cm vertical spikes; the spikes were inserted into the ground, and washers were used to join the spikes to the guard. This trap modification is beneficial in preventing damage to the pitfall trap or its contents by livestock.

More complex modifications have also been developed. Bostanian et. al. (1983) suggested a design for a ramp pitfall trap. Both the ramp and the roof of the trap were constructed of pressed, 0.71-mm thick, zinc-plated steel. A sliding plastic tray was used for collection and was located in the center of the ramp. On either side of the plastic tray, the ramp gradually sloped, resulting in a 9-degree angle with the ground. Each side of the ramp was treated with brown, metal primer paint, with the exception of the last 50 mm; instead, this area of the ramp, which was located next to the plastic tray, was treated with high-gloss car polish. The primer was applied to the ramp so that invertebrates could easily climb the ramp, while the polish provided a slippery surface, insuring that the individuals would fall into the trap.

Barrier pitfall traps have also been incorporated into studies of invertebrates. Reeves et. al. (1983) used an upright Plexiglas sheet (15 x 90 cm) with a three-container pitfall trap at both ends. The first container provided the outer liner; another container, pierced with a nail so that the head of the nail was in contact with the bottom of the first container, was placed inside (Reeves, 1980; Reeves et. al., 1983). The purpose of the nail was to provide easy removal of the container during sampling (Reeves, 1980). The last container was placed within these cups and contained a hole in the bottom, allowing the entry of invertebrates into the middle container, which served as the collecting tray (Reeves, 1980; Reeves et. al., 1983). For studies involving live capture, the outer liner and middle container were pierced with holes to prevent the accumulation of precipitation (Reeves, 1980). MacLean and Usis (1992) used barrier pitfall traps, which were separated by a distance of 10-15 m; a Plexiglas sheet (20 x 90 cm) provided a barrier. Plexiglas barriers, as well as metal guttering traps (Barney, 1980), help to increase the surface area sampled in a manner similar to the traps constructed by the ant lion *Callistoleon illustris*, recently discovered in Australia (Mansell, 1988). By creating trenches which converge into the trap, *Callistoleon illustris* directs invertebrates into its underground haven; as invertebrates are more likely to follow these natural trenches, it is also as probable that the invertebrates will follow along the Plexiglas barriers and be captured.

Another similar modification is the use of pitfalls in association with terrestrial drift fences. Gibbons and Semlitsch (1981) used aluminum flashing (50-cm height) to provide a drift fence, along which 20-L plastic buckets were placed on either side at 10-m intervals. In his study of the northern mole cricket, *Neocurtilla hexadactyla*, Semlitsch (1986) used 40-L buckets at 10-m intervals on each side of a terrestrial drift fence. In studies of centipedes, millipedes, and ground surface arachnids, Corey and

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Stout (1990, 1992) used four metal sheets (7.6-m length) as a drift fence, arranged so as to correspond to the cardinal directions. The sheets extended 40 cm above and 10 cm below the ground (Corey and Stout, 1992). Plastic buckets (approx. 21 L) served as the pitfall traps and were placed at the ends of the drift fence (Corey and Stout, 1990, 1992). At the midpoint of each arm, funnel traps were placed on each side; the funnel traps were composed of "fine-mesh" wire window screening. Gibbons and Semlitsch (1981) made several suggestions in regard to the construction of terrestrial drift fences. The mowing of vegetation, the addition of a layer of sand, and the filling of crevasses along the fence may benefit in increasing the probability that invertebrates will contact the trap. They also suggested that the addition of holes to either the bottom or the sides of the traps would prevent the accumulation of precipitation within the trap, that wet sponges could be placed in the bottom of the traps to prevent desiccation of captured invertebrates, and that installation of an electric wire system may prevent vertebrate disturbance of the traps. They also recommended that the spatial arrangement of the traps should be considered and that the traps should be checked "frequently."

An interesting collecting use is for subnivian (active under the snow) invertebrates, which poses specialized problems. Tardiff and Dindal (1980) devised a relatively simple aluminum/wood support with closure rod to open and close a glass jar pitfall trap. When opened, the resulting 2.5-cm airspace directly above the trap was thought to cause little change in the litter/soil microclimate, especially since no preservative was used. Another major advantage cited was the minimal disturbance to litter and to snow cover. However, repetitive samples cannot be collected with this design. Over an 8-day period, macro-invertebrate collections from five such traps as compared to those from two, 1-m circumference litter samples revealed mainly predators in the glass pitfalls and predators and detritivores in the litter samples. The authors suggested a combination of both techniques to adequately sample such an area under similar conditions. A more complex design includes a sunken trap with an overhead vertical cylinder to extend above snow cover and a horizontal disc to keep snow out of the trap (Steigen, 1973). A portable pumping device is inserted into this cylinder to withdraw the sample without disturbing the snow cover, and an "introscope" (periscope-like device) is then inserted to view the pitfall trap to confirm that all specimens have been removed. The latter was reported to not be necessary if proper procedures are followed.

Another more complex, specialized design involves the incorporation of a small 1.5- to 6.0-V DC hobby model motor to rotate a turntable to which are attached 19 plastic vials containing glycol (Ayre and Trueman, 1974). Specimens are directed by a funnel into each vial. A 365-day, battery-operated clock is the main component of the timing assembly and can time the collection of 18 samples during one day, one sample on each of 18 days, or some combination in between. Six 1.5-V "D" cell flashlight batteries provide power to the various components. This time-sort pitfall trap can thus operate for several days, eliminating ground disturbance to tend the trap. The entire unit fits into a 38-L plastic bucket in the ground and allows for the

accumulation of 10 cm of rain, with no roof to alter microclimate. The device will turn itself off at the end of the sampling period and will supposedly function for a year on one set of batteries.

SPECIFIC USES AND TECHNIQUES

Considerable variation exists insofar as the specified time intervals for collecting. Collections were made daily for approximately 2 weeks in a study conducted by Jagars op Akkerhuis and van der Voet (1992) and for approximately 2 months in a study of spiders by Freitag et. al. (1982). Samways (1983) sampled continuously for 72 h every 14th day for 6 months in his study of ants. Wharton and Seely (1982) used pitfall traps, which were checked every 2-7 days, to capture live beetles, which were counted and then released within 2-3 m of the traps. Samples may also be collected weekly (Reeves et. al., 1983) or biweekly (Vajda and Hornung, 1991), and collections have been made at irregular intervals during the sampling period (Hauge and Refseth, 1979). Snider and Calandrino (1987) collected samples during the day and at night. Corey and Taylor (1988) sampled their pitfall traps every two months in an eleven-month period, leaving the trap open for 14 days during each collection month, while Desender (1983) collected samples during 2-week periods at monthly intervals for two years. Once a month, Koch and Majer (1980) collected samples of invertebrates captured during a 7-day period; this was accomplished by replacing the uncorked test tube traps after each collection with tubes that remained corked until the next trapping period began.

Collections may also be seasonal. Bostanian et. al. (1983) collected samples for 2 years at 3-day intervals from ground thaw until first frost, while Corey and Stout (1990) sampled ground surface arachnids 4 days during each season for a 2-year period. Loring (1985) emptied traps during the summer for 6 periods of 5 days. Spider samples were collected monthly during the winter season, sampling from January to April, by Olynyk and Freitag (1977).

The placement and the number of the traps within the study site also vary. Kharboutli and Mack (1991) studied arthropods in peanut fields by dividing the fields into equal replicates; an equal number of pitfall traps (five) were placed both within and between the crop rows and were spaced at least 6 m apart. In one study of carabids and spiders, Freitag et. al. (1969) placed 10 pitfall traps at 4-m intervals in a line (east to west) within each study area. In another study of spiders, two lines of 25 pitfall traps were placed at 4-m intervals in each study site (Freitag et. al., 1982). Spacing between these two lines of traps was not indicated. Corey and Taylor (1987) placed three sets of 10 pitfall traps, separated by a distance of 10 m, within each study site; individual traps within sets were separated by a distance of 20-50 m. Snider and Snider (1986) separated four lines of pitfall traps by a distance of 4, 2, 1, and 0.5 m in evaluating variations in trap spacing within pitfall trap transects; the results of their study indicated that collection composition was not generally affected by spacing between traps but reflected species dominance at each transect site.

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In a study of terrestrial beetles in a Kentucky cave, Conn and DeMoss (1983) placed four pitfall traps in the upper level of the cave, four in the lower level, and one between levels. In South Africa, Samways (1983) set pitfall traps along a 10 x 170 m transect of 11 habitats associated with citrus; the community structure of ants in this transect was studied by placing four traps within each habitat in a 1-m square area. For desert arthropods, Pietruszka (1980) placed 49 traps at 5-m intervals; these traps were arranged so as to correspond with the cardinal directions, and a Malaise trap was located in the center. Loring (1985), in a study of the effects of gamma-radiation on *Collembola*, placed three sets of pitfall traps 10, 20, 40, 60, 80, and 100 m from a radiation source; the 9500 Ci cesium-137 radiation source operated 20 h per day (7 days per week).

The placement and number of trap-and-guard and barrier pitfalls also varied. Separated by a distance of 1.5 m, trap-and-guard pitfall traps were placed in two parallel rows (10 m apart), with each row containing 14 traps (Barratt and Campbell, 1982). MacLean and Usis (1992) placed five barrier pitfall traps in each of three study areas; the barrier pitfalls were separated by a distance of 10-15 m. Durkis and Reeves (1982) placed 10 rows of barrier pitfalls at a distance of approximately 15 m; six traps were placed in each row and were separated by approximately 7.5 m. During this study, traps with and without barriers were rotated in each row so as to minimize any bias involving the location of the traps.

In observing the effect of increased sampling on spiders and carabid beetles, Niemela et. al. (1986) initially used 15 pitfall traps separated by a distance of 2-3 m at each of 12 sites, which were similar in vegetation; during the second trapping period, the number of traps was increased to 30 in four sites and to 45 in another four sites, while the traps in the remaining sites numbered 15.

A study by Obertel (1971) on the number of traps needed to analyze adult Coleoptera collections taken over a 223-day period revealed some interesting aspects. Randomly using the collection results from each of 25 traps, it was determined that use of five traps accounted for 50% of the collected species. At least 20 traps were required to capture 90% of the species, and more than 25 traps would have been needed to capture all species in the area. Examining the "mutual ratio" of numbers of individuals of the 14 dominant Coleoptera species, Obertel found that 8-10 traps provided sufficient reliable data. Twelve traps provided sufficient quantitative data on average catches of individuals for most species. Since abundance may be a reflection of degree of invertebrate activity, the minimum number of traps necessary to show the "activity abundance" of Coleoptera was determined by analyzing the results from the use of 3, 6, 12, and 25 traps. Results indicated that 10-12 traps revealed the "average value of activity abundance of Coleoptera" in this study. The author emphasized that the extensive trapping period used in this study helped to ensure that most species would be sampled.

Moreover, pitfall traps have been used in a variety of habitats. Hauge et. al. (1978) placed pitfall traps in five locations, ranging from mid- to low-alpine habitats, in an effort to study the species composition of arthropods in South Norway. Invertebrate fauna has been studied in Scandinavian caves (Hippa et. al., 1986) as well as in forests and woodlands of western Australia (Koch and Majer, 1980). Spiders were studied in an abandoned field, oak forest, and beech-maple forest by Bultman et. al. (1982) so as to compare cursorial communities along a successional gradient, and were sampled in black spruce, jack pine, white birch, poplar, mixed forest, and meadow habitats by Freitag et. al. (1982). Corey and Taylor (1987) examined pond pine, sand scrub pine, and flatwoods communities in central Florida to determine the composition, abundance, and existing seasonal differences in the local scorpion, pseudoscorpion, and opilionid fauna. Also, centipedes and millipedes have been studied in 12 sandhill communities in north and central Florida (Corey and Stout, 1992). Anderson (1982) studied carrion beetles in deciduous forest, old field and meadow, marsh, and coniferous forest habitats in southern Ontario. Tree-scrub, bamboo, banana grove, and grazed grass habitats were sites in India chosen for a study of the ecology of dung beetles (Oppenheimer, 1977). Burying beetles were studied in southeastern woodlands (Trumbo, 1990) as was the carabid fauna in the upland oak forest of Michigan (Liebherr and Mahar, 1979). Ground beetles have also been collected by using pitfall traps in lowland, mixed mesophytic, and upland mixed oak forest habitats (MacLean and Usis, 1992) as well as in wheat, oat, barley, and rye fields (Dunn, 1982). Doane (1981) observed the diversity of ground beetles within a central Saskatchewan wheat field and its borders; collections of carabids at field borders yielded an increase in species diversity as compared to the collections in the field, indicating "edge effects."

Niemela (1988) studied the distribution patterns and habitat occupancy of carabids between the islands and the mainland of a region in southwest Finland. By choosing five habitats on each of five small islands, Niemela compared the results with those of trapping at three habitats, which were similar to those of the smaller islands, on the mainland; two additional habitats on the mainland were sampled. On six coastal islands in West Norway, Hauge et. al. (1991) chose 28 sites from which to sample spider species. In the central Namib Desert of South West Africa, Wharton and Seely (1982) placed pitfall traps in the Kuiseb river-bed and on the gravel plain so as to survey species composition in these locations. Watt (1980) used 12 pitfall traps along an altitudinal transect in order to sample the ground surface invertebrates among the differing vegetation in each location. In Scandinavia and West Norway, Otto and Svensson (1982) sought to determine the distribution of spider species along an altitudinal gradient of 0, 300, 600, and 800 m above sea level. Whelan et. al. (1980) set pitfall traps in locations of burned vegetation, unburned vegetation within a burned site, and unburned vegetation adjacent to the burned site in order to determine the effects of fire on arthropod populations. Pitfall traps have also been used in the aftermath of the Mt. St. Helens eruption; Klostermeyer et. al. (1981) studied the effects of the volcanic ash deposits on the local arthropod population.

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In some studies, the use of pitfall traps has involved other considerations and techniques. Soil samples, soil humidity, and temperature have been determined in the sampling site (Jagers op Akkerhuis and van der Voet, 1992). In addition, ground level precipitation has been measured daily (Semlitsch, 1986). During a study of Carolina-bay habitats involving the northern mole cricket, Semlitsch (1986) measured the depth of the bay weekly. The periodic drying and re-flooding of this bay was accompanied by movement of the crickets into and out of the bay bottom. In a study of the effects of minimum-tillage on spider activity, Mangan and Byers (1989) mowed and raked the experimental study areas before the placement of pitfall traps; some plots were seeded, while others remained unseeded. After the placement of vials into the nests of mound-building ants, Clark and Blom (1989) flagged the nests so that the vials could be relocated for collection.

Frequently, pitfall trapping is used in conjunction with additional collecting methods in order to compare efficiencies or to provide a more complete collection of invertebrates utilizing an area. Hippa et. al. (1986) captured invertebrates through hand collection as well as by pitfall traps; the pitfalls operated between the periods of hand collection. In a study of the carabid fauna associated with Michigan's upland oak forests, sticky boards, Malaise traps, pyrethrum spraying, and hand collecting were used in addition to pitfall traps (Liebherr and Mahar, 1979). Tullgren funnels have also been used to obtain litter samples to supplement pitfall catches (Snider and Calandrino, 1987). Richardson (1992) used pitfall traps accompanied by hand collections, trunk traps, and quadrat sampling. Burlese extraction was a method incorporated into a study of terrestrial beetles by Conn and DeMoss (1983), while Niemela et. al. (1988) used sweep-netting as an additional method in their study of carabid beetles. In preliminary trials utilizing sticky traps, nest counting, and quadrat sampling, Samways (1983) found that pitfall trapping provided the largest composition as well as the lowest variation in proportions of species of ants captured throughout the trapping period. Pitfall traps yielded a higher collection of cursorial arthropods (especially ants and mites) than did Malaise traps, which mainly yielded aerial insects (over 70% Diptera), in a study by Pietruszka (1980). Uetz and Unzicker (1976) indicated that species abundance of cursorial spiders was more accurately estimated by pitfall traps than by quadrat sampling in their study. However, relative abundances of carabid species in a study by Niemela et. al. (1988) were similar for sieving and hand-collecting as compared to pitfall trapping. MacLean and Usis (1992) used 16.5-cm delta-type pheromone traps set 1.5 m above the ground in order to collect gypsy moths, while barrier pitfalls were used to capture ground beetles which may be beneficial in controlling the gypsy moth. Trumbo (1990) studied burying beetles by using pitfall traps as well as randomly placed single mouse carcasses; the mice were approximately 25-40 g, and a 1-m length of dental floss was tied to the hind leg of each mouse. The dental floss aided in locating the carcasses after burial.

New species of invertebrates have been discovered through the use of pitfall traps, such as a new hydrophilid beetle from Mexico (Spangler and Huacuja, 1982) and numerous new species of spiders from Finland (Hippa and Mannila, 1974).

At the University of Montevallo, the senior author (Braid) has used pitfall traps as part of laboratory exercises in invertebrate zoology and general ecology courses. This practical exercise provides students with experience in randomizing treatments, identifying invertebrates through the use of dichotomous keys, and using the technique as a collecting aid.

PRESERVATIVES AND ATTRACTANTS

Preservatives and attractants may be added to the pitfall trap when attempting to capture specific invertebrates, although trapping of invertebrates may occur without the use of these. Greenslade and Greenslade (1971) investigated and reviewed the use of baits and preservatives in the collection of ants, and Lindeman (1991) found that unbaited and baited pitfall traps were equally efficient in trapping landhoppers in Costa Rica.

Clark and Blom (1992) used an ethylene glycol-based antifreeze as a preservative in the general capture of invertebrates, while Snider and Snider (1986) used ethylene glycol to capture arthropods. In a study of the tumble bug, *Deltochilum gibbosum gibbosum*, Barney (1980) half-filled traps of metal guttering with ethylene glycol. Ethylene glycol has also been used for collecting spiders (Hippa and Mannila, 1974) and opilionids (Hippa, 1975) as well as in studying native and alien landhoppers (Richardson, 1992) and the predators of *Bathyplectes curculionis* (Cherry and Armbrust, 1977). In studying cursorial spiders, Bultman et. al. (1982) filled traps with 5 cm of ethylene glycol. Predaceous arthropods were studied by Kharboutli and Mack (1991) by using approximately 250-mL ethylene glycol in each trap. Clark and Blom (1992) observed that flexibility of captured invertebrates, especially medium to large beetles, was retained to a greater extent in specimens exposed to ethylene glycol than to ethanol or cyanide. However, due to its sweet taste, ethylene glycol may be ingested by birds and mammals, possibly causing subsequent death. Hall (1991) recommended that pitfall traps containing ethylene glycol should be covered by "wide mesh" hardware cloth, or a bitter agent, such as quinine or denatonium benzoate, should be added to prevent such poisonings.

Moreover, the types and combination of substances within the trap may be diverse and vary in ratios and percentages. In studies of ants, alcohol has been used alone (Clark and Blom, 1989) or by filling 2 cm of each trap with 7 parts 70% ethyl alcohol/3 parts glycerol (Samways, 1981, 1983). Although Mangan and Byers (1989) studied spiders by placing approximately 50 mL of ethanol in each trap, Corey and Taylor (1987, 1988) studied scorpions, pseudoscorpions, opilionids, and ground surface spiders by using a 0.47-L mixture of ethylene glycol, water, and 95% ethanol in a 2:2:1 ratio. While studying ground surface arachnids (1990) as well as centipedes and millipedes (1992), Corey and Stout used this same solution in a 2:1:1 ratio. Carabids have been collected in some pitfalls traps containing 1-2 cm of ethylene glycol and water in a 2:1 ratio, while other traps were used for live capture (Liebherr

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and Mahar, 1979). Klostermeyer et. al. (1981) studied arthropods by using a 1:1 ethylene glycol antifreeze: 95% ethanol solution. Whelan et. al. (1980) used 5% glycerine in 70% ethanol in their study of arthropods, and spiders were studied by Otto and Svensson (1982) by using "a mixture" of ethylene glycol and alcohol. In studying invertebrates, Koch and Majer (1980) used 3 mL of a 7 parts alcohol/3 parts glycerol solution.

Pitfall traps contained 4% formalin solution in a study of arthropods, with 100 mL formalin per trap (Bishop and Holtkamp, 1982). This solution was also used in the collection of beetles and spiders (Bengtson and Hauge, 1979), for spiders alone (Hauge and Refseth, 1979; Jagars op Akkerhuis and van der Voet, 1992), and for chironomids (Moksnes, 1987). Desert arthropods were collected in 5% formalin (Pietruszka, 1980). Ground beetles were studied with traps containing either 150 mL of 10% formalin (MacLean and Usis, 1992) or a mixture of 5% formalin and 70% ethanol (Dritschilo and Wanner, 1980). Approximately 100 mL of 10% formalin was used by Reeves et. al. (1983) to study carabid beetles and by Bishop and Blood (1980) to study arthropod fauna. *Clivina fossor* has been studied by using a 10% formalin solution containing detergent for the reduction of surface tension (Desender, 1983).

Aqueous solutions of picric acid were used in studying spiders by filling traps to 1/3 of their depth (Jocque, 1981) and, saturated, as a fixative in a study of *Trechus obtusus* (Desender et. al., 1980). A small amount of liquid detergent was added to a 50% picric acid solution in a study of the striped chafer, *Odontia striata*, by Barratt and Campbell (1982) and in a study of broad-nosed weevils by Barratt (1981). Morrill (1976) suggested a solution described by Leech (1966); 600 mL water, 400 mL ethylene glycol, 5 mL formalin, and 1-2 mL detergent could be used to preserve specimens for "up to one week." Leibee et. al. (1981) also used this solution for the capture of the clover root curculio, *Sitona hispidulus*. Although detergent has been added to benzoic acid in the capture of carabids (Lyngby and Nielsen, 1980), an 80-g/L solution of tri-sodium orthophosphate (Bostanian et. al., 1983) or a solution of water and detergent (Niemela, 1988; Niemela et. al., 1989) has also been used.

In a general study of ground surface invertebrate fauna, Watt (1980) filled pitfall traps with 1/3 volume of 50% green anti-freeze (ethylene glycol) and 50% water, smelling of carrion and previously containing decayed chicken necks. A study of carrion beetle fauna was conducted by Anderson (1982) in which a 50:50 solution of water and ethylene glycol was used; approximately 200 g of fish (white sucker, or *Catostomus commersoni*) was placed in each trap as bait. In a study of troglophilic beetles, Conn and DeMoss (1984) baited pitfall traps, composed of glass vials, with approximately 5 g of spoiled pork liver; the bait was wrapped in cheesecloth and was hung into the trap by 6-mm mesh hardware cloth. Galt's solution also filled each trap to a depth of 2 cm (Conn and DeMoss, 1984). Trumbo (1990) studied burying beetles by placing 150-250 g carrion (*Rattus rattus*) in the traps. Spangler and

Huacuja (1982) baited traps with chicken viscera, bananas, fish, and cow and human feces in the collection of the hydrophilid beetle *Deltostethus scitulus*. In a study of dung beetles, the traps in each habitat were baited with human, monkey, dog, goat, cow, and buffalo dung (Gordon and Oppenheimer, 1975).

LIMITATIONS, PROBLEMS, AND BIASES

With any technique used to capture invertebrates, there exist limitations or problems which may bias or otherwise affect the sample. Pitfall traps are most efficient for collecting invertebrates crawling or running along the substrate surface and may not sample well those that fly or are found below the surface. Moreover, limitations may be attributed to the trap design, trap location, environmental conditions, preferences of particular species, or combination of these. Niemela et. al. (1986) observed that weather conditions, ground surface structure, trap type, and activity of the invertebrates in the vicinity of the trap affect the efficiency of sampling. Flooding of pitfall traps due to excessive rainfall occurred during food preference studies of birds (Moksnes, 1987). Collection could not be carried out in some sites due to "weather conditions" in a study of terrestrial spiders (Bengtson and Hauge, 1979). One must consider all such limitations when attempting to achieve an unbiased, representative sample.

Special consideration should be given to the purpose of the study. If the purpose is to measure general species composition within a designated location, possible limitations should be minimized so as to not promote the capture of a particular species. Relative population levels may be assessed through the use of pitfall traps (Greenslade, 1964; Luff, 1975; Reeves et. al., 1983). However, absolute population levels cannot be determined due to the mobility of species, seasonal shifts in habitat, or periods of inactivity (Oppenheimer and Tikader, 1976); pitfall trap samples reflect the ground activity of particular species in specific habitats rather than actual species abundance (Oppenheimer and Tikader, 1976; Watt, 1980).

Limitations may also be associated with the use of covers and preservatives or attractants. Although covers on the pitfall traps will reduce the accumulation of rain and soil litter in the traps, covers may attract certain species while repelling others. Environmental conditions or vertebrate disturbance may also remove these covers, resulting in problems with statistical analysis. The presence of preservatives and attractants may encourage, or even discourage, the capture of a particular species. According to Greenslade and Greenslade (1971), a significant percentage of flying insects in collections is "always" an indication of attraction to baits or preservatives. If traps do not contain preservatives, those invertebrates which are captured may escape, biasing the results of the study. Yet, upon checking traps containing ethylene glycol, ethanol, and water, Corey and Taylor (1987) found that many of the captured opilionids survived, implying that these opilionids may have an opportunity to escape despite the presence of the preservative. Since attractants may be used to capture

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particular species, Samways (1983) did not use baits in his study of ants so as to avoid the possibility of selective sampling when live trapping.

While evaluating ramp pitfalls as compared to plastic jar pitfalls, Bostanian et. al. (1983) found that ramp pitfalls tend to capture larger carabids (>10 mm) and plastic pitfalls efficiently capture carabids which are approximately 5-10 mm in length. They also remarked that the angle of the ramp may have induced smaller carabids to follow a downward path on the ramp, rather than the upward one which would have led them into the trap. Also, the darkness of the ramp due to the presence of a roof may have interfered with the capture of diurnal or some nocturnal species.

Invertebrate predators as well as their natural prey may be captured within traps; thus, the number of individuals or species may be significantly affected if the prey is devoured. Cannibalism among carabids necessitated weekly collections in one study (Olynyk and Freitag, 1977).

Invasion of the trap by small vertebrates or damage to the trap by larger vertebrates also presents problems. Durkis and Reeves (1982) discontinued their study involving carabids due to trap disturbance by raccoons. In plastic pitfall traps, the capture of small vertebrates, such as frogs, toads, and moles, led to the decay of captured arthropods (Bostanian et. al., 1983). Coincidental captures of earthworms, toads, frogs, lizards, snakes, shrews, and mice have occurred without causing trap damage (Wojcik et. al., 1972). Shrews and salamanders were captured during unpublished studies at the University of Montevallo.

Human activity in the sampling site may also affect the abundance of a particular species; for example, extensive mining in one of the caves studied by Hippa et. al. (1984b) may have contributed to the lack of lumbricids due to the unsuitable soil in the area.

The placement of the trap may also cause bias. The "digging in" effect may result from the recent placement of the trap in the ground. The activity of invertebrates within the immediate area can be temporarily increased due to this ground disturbance, thus artificially increasing the capture of invertebrates in that location and biasing the sample. Moreover, those invertebrates which usually evade capture are more likely to be trapped, further biasing the sample. Snider and Snider (1986) and Koch and Majer (1980) began their trapping period one week after the installation of the pitfall traps in order to avoid "digging-in" effects.

Biases may occur if pitfall trapping results in the "trapping out" of invertebrates (Klostermeyer et. al., 1981); sufficient distance between traps (in this study, traps were arranged in four rows 9.45 m apart and in three column 4.88 m apart) permits the populations in the immediate vicinity to be replenished, reducing biases in species abundance. A related phenomenon involves "trap-happy" and

"trap-shy" organisms which can bias quantitative estimates during mark-and-recapture studies (Wharton and Seely, 1982; Brower et. al., 1990). In the capture and release of carabids, Durkis and Reeves (1982) rotated pitfall traps with and without barriers in order to minimize possible bias regarding trap location; increasing the distance between the traps without barriers did not affect the numbers of carabids captured, while capture increased in the traps with barriers as barrier length was increased. Studying the effect of increased numbers of pitfall traps per site (15, 30, and 45 traps/site), Niemela et. al. (1986) observed that the sample composition remained fairly constant in regard to the spiders captured.

Consideration should also be given to the microclimate within the trap locality. Precipitation, humidity, minimum and maximum temperatures, and extreme environmental conditions may affect the capture of invertebrates. For example, *Zophosis (Calosis) amabilis* can tolerate heat and low humidity, while the activity of *Metriopus (Metriopus) depressus* and *Zophosis (Gyrosis) moralesi* increases following light rains and precipitating fogs (Wharton and Seeley, 1982). Excessive rainfall reduced the initial population of beetles and spiders captured during a study by Freitag et. al. (1969). Temporal changes in habitat may also promote changes in species abundance and diversity, so studies can differ in the same location over a period of time (Dondale, 1971; Corey and Taylor, 1988). Watt (1980) suggested that the microclimate as well as the vegetation in a location may be affected altitudinally, thereby possibly affecting species distribution. The presence or absence of vegetation within the site can promote or inhibit collection due to differences in temperature, soil humidity, or habitat preference; density and type of vegetation can also affect collection composition. For example, ant communities may be affected by the density of vegetation (Samways, 1983). Niemela's study of carabids (1988) between islands and the mainland demonstrated that the island site with the smallest proportion of vegetation yielded the lowest number of species; the island with the highest proportion of suitable habitats was found to have high species richness and sample size. Differences in the species abundance between the island and the mainland were also evident. The amount of foliage present in the immediate vicinity of the traps may affect whether covers are removed from the traps by the wind or whether the traps are filled with soil and precipitation; Kharboutli and Mack (1991) found that traps having more foliage coverage were less likely to be disrupted in this manner.

Seasonal activities of invertebrates may also affect sample size. Through pitfall trapping in a 3-year study, Vajda and Hornung (1991) observed that individuals of *Megaphyllum unilineatum* appear to have seasonal peaks during April, June, and October; the peak activities during this period were attributed to a favorable climate, increased activity of females after laying eggs, the appearance of mobile larvae, and the breeding season. Carabids exhibited seasonal occurrences in a study conducted by Ostaff and Freitag (1973). Niemela et. al. (1989) observed that the diversity of carabid species was lowest in May, increasing until July, and decreasing in late autumn.

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With regard to sex ratios and the capture of juveniles and adults, trapping may favor a particular sex or stage of development in certain species. For example, a study of millipedes (Julidae) by Meyer (1985) found that pitfall traps favored the capture of males, while hand collection and Tullgren funnels provided an unbiased sample of males and females in the same study; no immature individuals of *Ommatoiulus sabulosus* were captured in the traps. Hippa et. al. (1984a), studying invertebrates in Scandinavian caves, observed that illuminated regions of the caves were preferred by small juveniles of *Meta menardi*, while larger juveniles and adults appeared to avoid these areas. The opilionid *Mitopus morio* is trapped usually as a juvenile (Hippa, 1975).

CONCLUSION

Despite any obvious limitations with regard to pitfall traps, it is evident that the benefits of this technique are of greater significance. While pitfall traps have proven to be effective in the capture of invertebrates, recognition of variance in trap designs and their associated uses is important in the design of a particular study. Although differences exist in habitat preferences of species and prevailing environmental conditions, pitfall traps can be used to monitor the relative abundance of species within a particular location. Species interaction and habitat preference may be observed, further clarifying the importance of invertebrates in the environmental fauna. The quantitative and qualitative results of studies in one sampling site can only be compared with those from other sites if the same techniques are used. However, there is an obvious lack of consistency with regard to trap type and use of these. As we have shown, numerous trap types exist, and their spacing, number of replications, and preservatives are not standardized.

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LITERATURE CITED

- Anderson, R.S. 1982. Resource partitioning in the carrion beetle (Coleoptera: Silphidae) fauna of southern Ontario: ecological and evolutionary considerations. Can. J. Zool. 60: 1314-1325.
- Ayre, G.L. and D. K. Trueman. 1974. A battery operated time-sort pitfall trap. The Manitoba Entomol. 8: 37-40.

- Barney, R.J. 1980. First report of *Deltochilum gibbosum gibbosum* (F.) in Illinois (Coleoptera: Scarabaeidae). The Coleopterists Bull. 34(1): 84-85.
- Barratt, B.I.P. 1981. Insect damage to white clover oversown into New Zealand native tussock grassland. Proc. 3rd Australasian Conf. Grassl. Invert. Ecol., Adelaide 30 Nov. - 4 Dec.: 25-31.
- Barratt, B.I.P. and R.A. Campbell. 1982. Biology of the striped chafer, *Odontria striata* (Coleoptera: Scarabaeidae) I. The adult, flight and ground surface activity, female reproductive maturation, and food-plant selection. New Zealand J. Zool. 9: 249-266.
- Bengtson, S. and E. Hauge. 1979. Terrestrial invertebrates of the Faroe Islands: I. Spiders (Araneae): Check-list, distribution, and habitats. Fauna norv. ser. B. 26: 59-83.
- Bishop, A.L. and P.R.B. Blood. 1980. Arthropod ground strata composition of the cotton ecosystem in South-Eastern Queensland, and the effect of some control strategies. Aust. J. Zool. 28: 693-697.
- Bishop, A.L. and R. H. Holtkamp. 1982. The arthropod fauna of Lucerne in the Hunter Valley, New South Wales. Gen. Appl. Ent. 14: 21-32.
- Bostanian, N. J., G. Boivin, and H. Goulet. 1983. Ramp pitfall trap. J. Econ. Entomol. 76(6): 1473-1475.
- Bultman, T.L., G.W. Uetz, and A.R. Brady. 1982. A comparison of cursorial spider communities along a successional gradient. J. Arachnol. 10: 23-33.
- Brower, J., J. Zar, and C. von Ende. 1990. Field and laboratory methods for general ecology. 3rd ed. Wm. C. Brown Publishers, Dubuque. 192p.
- Cherry, R.H. and E.J. Armbrust. 1977. Predators of *Bathyplectes curculionis* [Hym.: Ichneumonidae], a parasite of *Hypera postica* [Col.: Curculionidae]. Entomophaga 22(3): 323-329.
- Clark, W.H. and P.E. Blom. 1989. A collection technique for mound-building ants (Hymenoptera: Formicidae). Ent. News 100(3): 127-128.
- Clark, W.H. and P.E. Blom. 1992. An efficient and inexpensive pitfall trap system. Ent. News 103(2): 55-59.
- Conn, D.B. and G.L. DeMoss. 1983. Terrestrial beetles (Coleoptera) of Bat Cave, Carter County, Kentucky. Trans. Ky. Acad. Sci. 44(1-2): 29-33.

The Pitfall Trap

- Conn, D.B. and G.L. DeMoss. 1984. Distribution of four troglophilic beetles in a *Myotis sodalis* (Chiroptera) hibernaculum. Coleopterists Bull. 38(3): 251-255.
- Corey, D.T. and I.J. Stout. 1990. Ground surface arachnids in sandhill communities of Florida. J. Arachnol. 18: 167-172.
- Corey, D.T. and I.J. Stout. 1992. Centipede and millipede (Chilopoda and Diplopoda) faunas in sandhill communities of Florida. Am. Midl. Nat. 127: 60-65.
- Corey, D.T. and W.K. Taylor. 1987. Scorpion, pseudoscorpion, and opilionid faunas in three central Florida plant communities. Florida Sci. 50(3): 162-167.
- Corey, D.T. and W.K. Taylor. 1988. Ground surface spiders in three central Florida plant communities. J. Arachnol. 16: 213-221.
- Desender, K. 1983. Ecological data on *Clivina fossor* (Coleoptera, Carabidae) from a pasture ecosystem I. Adult and larval abundance, seasonal and diurnal activity. Pedobiologia 25: 157-167.
- Desender, K., J.-P. Maelfait, and R. Deurinck. 1980. Ecological data on *Trechus obtusus* De Geer (Coleoptera, Carabidae) collected by pitfall trapping in coastal dunes (Belgium). Biol. Jb. Dodonaea 48: 90-101.
- Doane, J.F. 1981. Seasonal captures and diversity of ground beetles (Coleoptera: Carabidae) in a wheat field and its grassy borders in Central Saskatchewan. Quaestiones Entomologicae 17: 211-233.
- Dondale, C.D. 1971. Spiders of Heasman's field, a mown meadow near Belleville, Ontario. Proc. ent. Soc. Ont. 101: 62-69.
- Dritschilo, W. and D. Wanner. 1980. Ground beetle abundance in organic and conventional corn fields. Environ. Entomol. 9(5): 629-631.
- Dunn, G.A. 1982. Ground beetles (Coleoptera: Carabidae) collected by pitfall trapping in Michigan small-grain fields. Great Lakes Entomol. 15(1): 37-38.
- Durkis, T.J. and R.M. Reeves. 1982. Barriers increase efficiency of pitfall traps. Ent. News 93(1): 25-28.
- Freitag, R., B.L. Barnes, R. Tropea, and R.E. Leech. 1982. An annotated list of spiders collected during the "Big Dig" near Wawa, Ontario, 1971. Candian-Field Naturalist (96(4)): 383-388.

- Freitag, R., G.W. Ozburn, and R.E. Leech. 1969. The effects of Sumithion and Phosphamidon on populations of five carabid beetles and the spider *Trochosa terricola* in Northwestern Ontario and including a list of collected species of carabid beetles and spiders. Canadian Entomol. 101(12): 1328-1333.
- Gibbons, J.W. and R.D. Semlitsch. 1981. Terrestrial drift fences with pitfall traps: An effective technique for quantitative sampling of animal populations. Brimleyana 7: 1-16.
- Gordon, R.D. and J.R. Oppenheimer. 1975. Taxonomy and ecology of two species of Indian *Onthophagus* (Coleoptera: Scarabaeidae). Oriental Insects 9(4): 495-501.
- Greenslade, P.J.M. 1964. Pitfall trapping as a method for studying populations of Carabidae (Coleoptera). J. Anim. Ecol. 33: 301-310.
- Greenslade, P. and P.J.M. Greenslade. 1971. The use of baits and preservatives in pitfall traps. J. Aust. ent. Soc. 10: 253-260.
- Hall, D.W. 1991. The environmental hazard of ethylene glycol in insect pit-fall traps. Coleopterists Bull. 45(2): 193-194.
- Hauge, E., A. Bruvoll, and T. Solhoy. 1991. Spiders (Araneae) from islands of Oygarden, West Norway. Species associations, with ecological and zoogeographical remarks. Fauna norv. Ser. B. 38: 11-26.
- Hauge, E., S. Hagvar, and E. Ostbye. 1978. Pit-fall catches of surface-active arthropods in some high mountain habitats at Finse, south Norway. III. The species of Araneida. Norw. J. Ent. 25: 207-220.
- Haughe, E. and D. Refseth. 1979. The spider fauna of 5 alpine and subalpine habitats in the Jotunheimen area, southern Norway. Fauna norv. Ser. B. 26: 84-90.
- Hippa, H. 1975. Faunistic and ecological notes on the opilionid fauna (Opilionida) of South-west Hame, Finland. Lounais-Hameen Luonto 55:1-4.
- Hippa, H., S. Koponen, and R. Mannila. 1984a. Invertebrates of Scandinavian caves I. Araneae, Opiliones, and Pseudoscorpionida (Arachnida). Annales Entomologici Fennici 50: 23-29.
- Hippa, H., S. Koponen, R. Mannila, and J. Terhivuo. 1984b. Invertebrates of Scandinavian caves II. Lumbricidae (Oligochaeta). Memoranda Soc. Fauna Flora Fennica 60: 78-80.

The Pitfall Trap

- Hippa, H., S. Koponen, and R. Mannila. 1986. Invertebrates of Scandinavian caves V. Diplopoda, Chilopoda, Isopoda, and Amphipoda. *Memoranda Soc. Fauna Flora Fennica* 62: 1-4.
- Hippa, H. and R. Mannila. 1974. Faunistic and ecological notes on the spider fauna (Araneae) of South-west Hame, Finland. *Lounais-Hameen Luonto* 52: 1-27.
- Hippa, H. and R. Mannila. 1975. Ecological and faunistic data on the spider fauna (Araneae) of South-west Hame, Finland. *Lounais-Hameen Luonto* 55: 5-16.
- Jagars op Akkerhuis, G.A.J.M. and H. van der Voet. 1992. A dose-effect relationship for the effect of deltamethrin on a linyphiid spider population in winter wheat. *Arch. Environ. Contam. Toxicol.* 22: 114-121.
- Jocque, R. 1981. On reduced size in spiders from marginal habitats. *Oecologia (Berl)* 49: 404-408.
- Kharboutli, M.S. and T.P. Mack. 1991. Relative and seasonal abundance of predaceous arthropods in Alabama peanut fields as indexed by pitfall traps. *J. Econ. Entomol.* 84(3): 1015-1023.
- Klostermeyer, E.C., L.D. Corpus, and C.L. Campbell. 1981. Population changes in arthropods in wheat following volcanic ash fall-out. *Melanderia* 37: 45-49.
- Koch, L.E. and J.D. Majer. 1980. A phenological investigation of various invertebrates in forest and woodland areas in the south-west of Western Australia. *J. Royal Soc. Western Australia*. 63(part I): 21-28.
- Leech, R.E. 1966. The spiders of Hazen Camp 81° 49'N, 70° 18'W. *Quæstiones Entomol.* 2: 153-212.
- Leibee, G.L., B.C. Pass, and K.V. Yeargan. 1981. Seasonal abundance and activity of *Sitona hispidulus* adults in Kentucky. *Environ. Entomol.* 10(1): 27-30.
- Liebherr, J. and J. Mahar. 1979. The carabid fauna of the upland oak forest in Michigan: Survey and Analysis. *Coleopterists Bull.* 33(2): 183-197.
- Lindeman, D. 1991. Natural history of the terrestrial amphipod *Cerrorchestia hyloraina* Lindeman (Crustacea: Amphipoda; Talitridae) in a Costa Rican cloud forest. *J. Natural Hist.* 25: 623-638.

- Loring, S.J. 1985. Gamma radiation effects on Collembola. *Environ. Entomol.* 14(6): 805-809.
- Luff, M.L. 1975. Some factors influencing efficiency of pitfall traps. *Oecologia* 19: 345-357.
- Lyngby, J.E. and H.B. Nielsen. 1980. The spatial distribution of carabids (Coleoptera: Carabidae) in relation to a shelterbelt. *Ent. Meddr.* 48: 133-140.
- MacLean, D.B. and J.D. Usis. 1992. Ground beetles (Coleoptera: Carabidae) of eastern Ohio forests threatened by the gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae). *Ohio J. Sci.* 92(3): 46-50.
- Majer, J.D. 1978. An improved pitfall trap for sampling ants and other epigaeic invertebrates. *J. Aust. ent. Soc.* 17: 261-262.
- Mangan, R.L. and R.A. Byers. 1989. Effects of minimum-tillage practices on spider activity in old-field swards. *Environ. Entomol.* 18(6): 945-952.
- Mansell, M.W. 1988. The pitfall trap of the Australian ant-lion *Callistoleon illustris* (Gerstaeker) (Neuroptera: Myrmeleontidae): An evolutionary advance. *Aust. J. Zool.* 36: 351-356.
- Meyer, E. 1985. Distribution, activity, life-history and standing crop of Julidae (Diplopoda, Myriapoda) in the Central High Alps (Tyrol, Austria). *Holarctic Ecol.* 8: 141-150.
- Moksnes, A. 1987. Food biology of ringed plover *Charadrius hiaticula* and Temminck's Stint *Calidris temminckii* in the regulation zone of a hydroelectric power reservoir. *Fauna norv. Ser. C, Cinclus* 10: 103-113.
- Morrill, W.L. 1976. Plastic pitfall trap. *Environ. Entomol.* 4: 596.
- Niemela, J. 1988. Habitat occupancy of carabid beetles on small islands and the adjacent Aland mainland, SW Finland. *Ann. Zool. Fennici* 25: 121-131.
- Niemela, J., Y. Haila, E. Halme, T. Lahti, T. Pajunen, and P. Punttila. 1988. The distribution of carabid beetles in fragments of old coniferous taiga and adjacent managed forest. *Ann. Zool. Fennici* 25: 107-119.
- Niemela, J., Y. Haila, E. Halme, T. Pajunen, and P. Punttila. 1989. The annual activity cycle of carabid beetles in the southern Finnish taiga. *Ann. Zool. Fennici* 26: 35-41.

The Pitfall Trap

- Niemela, J., E. Halme, T. Pajunen, and Y. Haila. 1986. Sampling spiders and carabid beetles with pitfall traps: the effect of increased sampling effort. Ann. Entomol. Fennici 52: 109-111.
- Obrelt, R. 1971. Number of pitfall traps in relation to the structure of the catch of soil surface Coleoptera. Acta ent. bohemoslov. 68: 300-309.
- Olynyk, J. and R. Freitag. 1977. Collections of spiders beneath snow. Canadian Field-Naturalist 91(4): 401-402.
- Oppenheimer, J.R. 1977. Ecology of dung beetles (Scarabaeidae: Coprinae) in two villages of West Bengal. Rec. Zool. Surv. India 72: 389-398.
- Oppenheimer, J.R. and B.K. Tikader. 1976. The ground activity of spiders (Araneae) and Harvestmen (Phalangidae) in West Bengal, India. J. Bombay Natural Hist. Soc. 73(1): 121-141.
- Ostaff, D.P. and R. Frietag. 1973. Phenology of carabid beetles of Thunder Bay and their associated mite population. Entomol. Soc. Ontario. 104: 34-37.
- Otto, C. and B.S. Svensson. 1982. Structure of communities of ground-living spiders along altitudinal gradients. Holarctic Ecol. 5: 35-47.
- Pietruszka, R.D. 1980. Observations on seasonal variation in desert arthropods in central Nevada. Great Basin Naturalist 40(3): 292-297.
- Reeves, R.M. 1980. Use of barriers with pitfall traps. Ent. News 91(1): 10-12.
- Reeves, R.M., G.A. Dunn, and D.T. Jennings. 1983. Carabid beetles (Coleoptera: Carabidae) associated with the spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). Can. Ent. 115: 453-472.
- Richardson, A.M.M. 1992. Altitudinal distribution of native and alien landhoppers (Amphipoda: Talitridae) in the Ko'olau range, O'ahu, Hawaiian Islands. J. Natural Hist. 26: 339-352.
- Samways, M.J. 1981. Comparison of ant community structure (Hymenoptera: Formicidae) in citrus orchards under chemical and biological control of red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae). Bull. ent. Res. 71: 663-670.
- Samways, M.J. 1983. Community structure of ants (Hymenoptera: Formicidae) in a series of habitats associated with citrus. J. Applied Ecol. 20: 833-847.

- Semlitsch, R.D. 1986. Life history of the northern mole cricket, *Neocurtilla hexadactyla* (Orthoptera: Gryllotalpidae), utilizing Carolina-bay habitats. Ann. Entomol. Soc. Am. 79: 256-261.
- Snider, R.J. and F.J. Calandrino. 1987. An annotated list and new species descriptions of Collembola found in the project ELF study area of Michigan. Great Lakes Entomol. 20(1): 1-19.
- Snider, R.M. and R.J. Snider. 1986. Evaluation of pit-trap transects with varied trap spacing in a northern Michigan forest. Great Lakes Entomol. 19(2): 51-61.
- Spangler, P.J. and A.H. Huacuja. 1982. *Deltostethus scitulus*, a new hydrophilid beetle from Mexico (Coleoptera: Hydrophilidae). Ent. News 93(1): 1-7.
- Steigen, A.L. 1973. Sampling invertebrates active below a snow cover. OIKOS 24: 373-376.
- Strandberg, J.O. 1981. Activity and abundance of the earwig, *Labidura riparia*, in a winter cabbage production ecosystem. Environ. Entomol. 10(5): 701-704.
- Strandberg, J.O. and L.C. Tucker. 1974. *Filariomyces forficulae*: Occurrence and effects on the predatory earwig, *Labidura riparia*. J. Invert. Pathology 24: 357-364.
- Tardiff, M.F. and D.L. Dindal. 1980. A method for pitfall trapping active subnivian invertebrates. J. Georgia Entomol. Soc. 15(1): 41-46.
- Trumbo, S.T. 1990. Reproductive success, phenology and biogeography of burying beetles (Silphidae, Necrophorus). Am. Midl. Nat. 124: 1-11.
- Uetz, G.W. and J.D. Unzicker. 1976. Pitfall trapping in ecological studies of wandering spiders. J. Arach. 3: 101-111.
- Vajda, Z. and E. Hornung. 1991. Temporal and spatial pattern of a diplopod population (*Megaphyllum unilineatum*) (C.L. Koch)) in a sandy grassland. Acta Biol. Szeged. 37: 75-81.
- Watt, J.C. 1980. Notes on pitfall trapping on Headlong Park, Mount Aspiring National Park. New Zealand Entomol. 7(2): 184-191.
- Wharton, R.A. and M. Seely. 1982. Species composition of and biological notes on Tenebrionidae of the lower Kuiseb River and adjacent gravel plain. Madoqua 13(1): 5-25.

The Pitfall Trap

- Whelan, R.J., W. Langedyk, and A.S. Pashby. 1980. The effects of wildlife on arthropod populations in Jarrah-*Banksia* woodland. Western Australian Naturalist 14(8): 214-220.
- Wojcik, D.P., W.A. Banks, D.M. Hicks, and J.K. Plumley. 1972. A simple inexpensive pitfall trap for collecting arthropods. Florida Entomol. 55(2): 115-116.

CARPAL TUNNEL SYNDROME RESEARCH AT AUBURN UNIVERSITY¹

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ABSTRACT

Since the mid-1980s, the Department of Industrial Engineering at Auburn University, Alabama, has researched the assessment and control of musculoskeletal cumulative trauma disorders of the upper extremities, with a focus on carpal tunnel syndrome. Seven research projects and a scientific conference have supported both national and regional needs, and future research projects and related activities will continue to do so.

INTRODUCTION

Cumulative trauma disorders (CTDs) of the musculoskeletal system are one of the most frequent classes of illnesses in the workplace. Data for 1992 show that slightly more than 62% of new workplace illnesses were CTD-related (U.S. Department of Labor, 1993). These statistics are consistent with a trend whereby CTDs, particularly those associated with the upper extremities (i.e., shoulders, arms, and hands), have increased steadily since the early 1980s.

The most pervasive of the upper extremity CTDs is carpal tunnel syndrome (CTS). CTS results from compression of the median nerve where it passes through the carpal tunnel from the wrist to the hand. The pressure on or pinching of the nerve is caused by congestion due to irritation-induced swelling of the 9 flexor tendons that also pass through the carpal tunnel.

Symptoms often occur at night when fluid accumulates in the tendon sheaths, diminishing circulation to the median nerve and, thus, adversely affecting areas of the hand that it innervates: most of the palm, the thumb, index finger, middle finger, and half of the ring finger (fig. 1). These symptoms can include hypesthesia (diminished sensitivity to stimulation), paresthesia (a burning, prickling, tingling, or crawling sensation of the skin), muscle atrophy, or weakness.

Excessive wrist deviation can cause CTS, especially when a person repeatedly grasps an object and exerts strong forces with the fingers. The effects of these risk

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factors can be even more severe if accompanied by pressure from hard work surfaces and tools and by vibration and cold from environmental exposure (Alexander and Pulat, 1985; Feldman et al., 1983; Putz-Anderson, 1988).

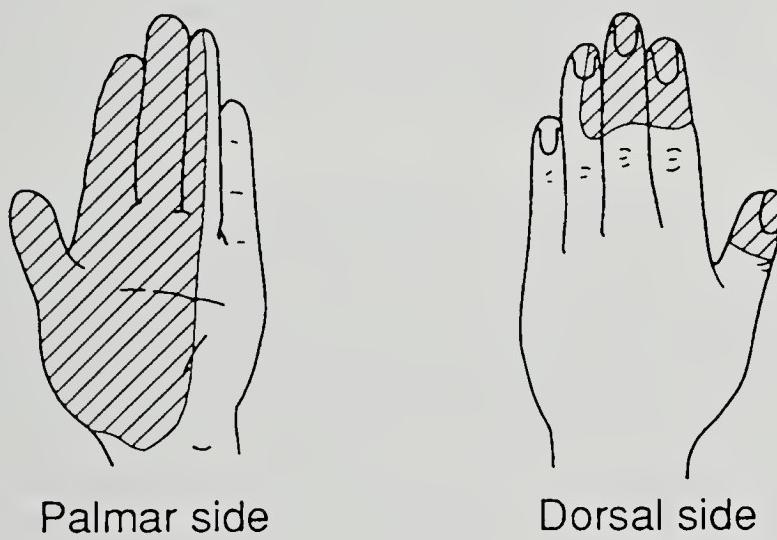


Figure 1. CTS symptoms are confined to areas innervated by the median nerve.

Also, nonoccupational activities that stress the musculoskeletal system of the upper extremities can cause CTS. Hobbies such as knitting, sewing, or playing musical instruments have been associated with CTS development. Some systemic diseases such as rheumatoid arthritis, hypertension, and diabetes, or a condition such as pregnancy may also predispose persons to many common CTDs (Putz-Anderson, 1988).

Industries most affected by CTDs commonly require intensive hand-arm motion tasks. The meat products industry, for example, had 5660 incidences of CTD per 100,000 full-time workers in 1989. This rate is in contrast to the 689 incidences per 100,000 workers in general manufacturing, and to the 192 incidences per 100,000 workers in all occupations (U.S. Public Health Service [USPHS], 1992).

Although exact statistics are not available, in the Southeastern United States CTS occurs often in industries such as apparel and textile manufacturing, poultry processing, tire manufacturing, and automobile production.

The economic impact of CTS, although not precisely known, has been substantial. While an average CTS case may cost an employer \$3500 to \$30,000, some serious cases have cost employers up to \$100,000 (Snook, 1989; Moore, 1991; Horsford, 1992). Insurance officials generally acknowledge that CTS has been one of the primary causes of large increases in direct medical costs and workers'

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compensation in recent years (Thomas, 1991a, b, and c). Though official estimates vary greatly, most authorities believe the direct medical costs and workers' compensation from these disorders are \$29 billion to \$40 billion annually in the United States. The total cost is believed to be at least double these costs plus any additional costs resulting from the reduced quality of products and services produced by a worker who suffers from such disorders, but who stays on the job for economic and other personal reasons (National Institute for Occupational Safety and Health [NIOSH], 1993).

COMMUNITY'S RESPONSE TO CTS

Nationally and regionally the occupational health community is responding to CTD and CTS problems. But it was not until 1985, when NIOSH and the Association of Schools of Public Health held the National Symposium on the Prevention of Leading Work-related Diseases and Injuries, that the CTD problem received national attention. From that symposium, NIOSH (1986) developed "A Proposed National Strategy for the Prevention of Musculoskeletal Injuries." That document outlines broad tactical approaches as well as intermediate and future actions needed to understand and prevent various occupational musculoskeletal injuries, including CTS.

At the National Strategy for Occupational Musculoskeletal Injury Prevention conference held at the University of Michigan in April 1991 (NIOSH, 1993), participants developed recommendations to guide research toward a better understanding of CTD causes and to develop, implement, and evaluate various CTD-hazard surveillance and CTD-injury control and prevention strategies.

In 1990, the U.S. Department of Health and Human Services supplemented NIOSH's work by establishing the "Healthy People 2000: National Health Promotion and Disease Prevention Objectives." The focus of the occupational safety and health part of these objectives included CTDs, and recognized CTS as one of the most prevalent forms of musculoskeletal disorders. A goal was set: Reduce by 40% the CTD overall rate of 100 cases per 100,000 workers in 1987 to 60 cases per 100,000 workers by 2000 (USPHS, 1990).

AUBURN UNIVERSITY'S RESPONSES TO CTS

In 1985-86, the Department of Industrial Engineering at Auburn University developed a series of research projects to support the national objectives of helping regional industries assess and control CTS. Thermography, nerve conduction, electromyography, and various subjective techniques were used to investigate the control processes--physical exercise, biofeedback, and workplace design. These research projects are reviewed chronologically here.

1. "An Evaluation of Infrared Thermography for Use in a Carpal Tunnel Syndrome Control Program" (Merritt, 1987). This research project evaluated infrared thermography's potential application for surveillance of CTS control programs in industry. Thermograms were made of the hands of two groups and were evaluated by a physician. The hands of one group of 18 subjects were diagnosed as symptomatic of CTS, and the hands of the other group of 17 control subjects were diagnosed as asymptomatic of CTS.

Temperature data from the two groups were used to develop a discriminant function and a scheme for classifying thermograms of unknown hand pathology. A hand-cooling routine was used to increase CTS detectability, with themograms made before and after each subject's hands were cooled. Also, pinch strength, grip strength and sensitivity were measured for each subject. Mean skin temperatures were calculated from the thermograms, and maximum and minimum temperatures were determined. The thermograms were analyzed with linear discriminant techniques and nonparametric nearest neighbor analyses. Posterior probabilities from these analyses were averaged and used to develop a quartile classification scheme. Results showed that temperature data from thermograms alone can be used reliably and objectively to detect CTS and that thermography is sufficiently reliable to surveil CTS in industry.

2. "Exercise as a Prophylactic Device Against Carpal Tunnel Syndrome" (Williams, 1989, and Williams et al., 1989). This research investigated the null hypothesis that participating in an on-the-job strength and flexibility exercise program as an intervention measure to prevent musculoskeletal stress has no effect against CTS. Data from grip strength measurements, Phalen's tests, and hand/wrist thermograms (using liquid crystal thermography) were collected from a group of female garment workers who were doing moderate-risk, hand-intensive tasks during a 10-week exercise program. These data were then compared to similar data taken from a control group of workers who did not participate in the program. Results suggested that the exercise program may have had some benefit, but the null hypothesis could not be rejected.

3. "A Computer-aided Algorithm for the Identification of Thermal Histograms Which Represent Asymptomatic Hands" (Kennedy, 1990). The objectives of this research were to create and evaluate a computer-based program that could be used on-site at an industry to screen thermograms of workers' hands for CTS symptoms. The program was used in conjunction with a scanner that digitized thermal information from a Polaroid picture. With the thermogram digitized, the program was used to construct histograms based on the temperature distributions of the thermographic data.

For 10 female subjects whose hands had been diagnosed as asymptomatic of median nerve neuropathies, palmar-view thermograms were made and evaluated. The temperature histograms and temperature means of the thermographic data were

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calculated by the program and then statistically compared to determine if the histogram distributions were consistent among the group. A null hypothesis that the temperature distributions of the collected data were independent was analyzed statistically. The results indicated that temperature distributions were not consistent in persons whose hands were asymptomatic of median nerve neuropathies.

4. "The Effects of Biofeedback on Carpal Tunnel Syndrome" (Vaidya, 1990; Thomas et al., 1993a). This research used behavior modification based on a biofeedback device that monitored electrical activity in the forearm muscles. The null hypothesis was that line workers' participation in a biofeedback program used as an intervention measure had no effect on CTS. Grip strength, motor nerve conduction latency, and relative body-part discomfort were tested before and during the 8-week study. Data were collected from two groups of five females each who did light hardware-assembly tasks in an industrial facility. One group used the biofeedback device while working; the other did not.

Statistical analysis of the data indicated the null hypothesis could not be rejected. However, no complaints of CTS were reported. Two subjects from the biofeedback group felt that the program was effective while the rest found it to be of little value in work-modification. The biofeedback group experienced the least change in grip strength. At the final test, none of the subjects from either group showed symptoms of nerve dysfunction in the hands. Participating in the program appeared to be psychologically beneficial although no statistically significant physiological changes were noted.

5. "Effects of Exercise on Carpal Tunnel Syndrome Symptoms" (Butterfield, 1990; Thomas et al., 1993b). This was a study of whether participation in an exercise program for increasing upper extremity flexibility, strength, and circulation has any effect on CTS symptoms. Research was done on-site at a Southeastern U.S. industry. Two groups (exercise and control) of seven participants each who did repetitive hand-motion tasks were studied. The exercise group participated in daily arm, hand, and other upper extremity exercises for 8 weeks. The control group did not participate in the exercise program. Dependent response variables monitored were motor nerve conduction latency through the carpal tunnel, grip strength, and subjective comfort in the dominant hands of the participants. Test results indicated no statistically significant differences in nerve conduction latency or subjective comfort between groups. Significant differences did develop in grip strengths over time, suggesting that the exercise group may have benefited physiologically from the exercise program.

6. "An Electromyographic Evaluation of the Kinesis™ Ergonomic Computer Keyboard" (Gerard, 1992). An increase in keyboard use in connection with word processors and computers has been associated with an increase in CTD and in CTS incidences. Traditional keyboards induce undesirable (nonneutral) arm and hand

postures that increase forearm and hand muscular activity associated with CTD and CTS development. This study analyzed the electromyographic activity in four muscle groups in a subject's forearms while the subject typed at a keyboard of alternative design--the Kinesis™ ergonomic computer keyboard. This keyboard's split design and key layouts fit each hand and allow neutral arm and hand postures. The stresses were compared to the stresses recorded while typing on a traditional keyboard. Data analyses indicated that when the operator assumed a touch-typing posture at the Kinesis™ keyboard, significantly less stress occurred in the flexor carpi ulnaris and the flexor digitorum sublimis muscles of the forearms.

7. "Carpal Tunnel Syndrome: A Review of Detection Methods and the NIOSH Case Definition in an Industrial Environment" (Horsford, 1992). This current research project at Auburn University is investigating various motor, sensory, physical, and subjective techniques for diagnosing occupational CTS. The objectives are to: assess a set of CTS detection methods that could be used, under direct or indirect medical supervision, at work sites; evaluate the NIOSH case definition for CTS; and evaluate alternative test combinations/detection protocols based on information collected from individual tests. Eighteen women whose primary job functions include keyboard data entry have been tested for CTS. Results will be compared to a physician's medical assessment. Test sensitivity, specificity, and predictive value will be calculated. Also, the impact of age, length of time in job, and the time of day that testing is done will be studied.

MULTIDISCIPLINARY CONFERENCE

In 1991, the Department of Industrial Engineering at Auburn University developed and directed a 2 1/2-day conference: "Control and Prevention of Cumulative Trauma Disorders in the Textile, Apparel and Fiber Industries." More than 210 persons from 25 states attended. A multidisciplinary group representing government, management, labor, consulting, academia, insurance, and legal organizations presented their views and perspectives on CTD issues and discussed them frankly. The consensus was that: 1) the occupational causes of CTDs are still not well understood; 2) CTD research needs to be emphasized; and 3) the best CTD defense is a strong proactive ergonomics program (Thomas, 1991a, b, and c).

SUMMARY

Since the mid-1980s, the Auburn University Department of Industrial Engineering has supported national objectives of countering CTD and CTS. A series of research projects investigated the utility and effectiveness of assessment techniques such as thermography, nerve conduction, electromyography, and subjective responses. Control processes were also examined and included physical exercise, biofeedback, and workplace design. And, research was complemented with the hosting of a

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nationally advertised multidisciplinary conference in 1991. During this 2 1/2-day conference, representatives from government, management, labor, consulting, academia, insurance, and legal organizations exchanged views on CTDs, including CTS.

FUTURE RESEARCH

In future CTD/CTS issues, the Department of Industrial Engineering at Auburn University will focus on research and on dissemination of the results. Research will include one project that evaluates the utility and effectiveness of CTD risk assessment methods such as the repetitive upper limb assessment (RULA) technique (McAtamney and Corlett, 1993). Another research project will include the design and evaluation of a simplified technique for pinpointing CTD causes. The research results will be disseminated to regional and national consumers through extension seminars, panels, televised lectures, and written communications.

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LITERATURE CITED

- Alexander, D.C., and Pulat, B.M. (1985). *Industrial Ergonomics*. Industrial Engineering and Management Press, Norcross, GA, p. 241.
- Butterfield, R.K. (1990). Effects of exercise on carpal tunnel syndrome symptoms. Master of Science Thesis, Auburn University, AL.
- Feldman, R.G., Goldman, R., and Keyserling, W.M. (1983). Classical syndromes in occupational medicine. Peripheral nerve entrapment syndromes and ergonomic factors. *American Journal of Industrial Medicine*, 4(5), pp. 661-681.
- Gerard, M.J. (1992). An electromyographic evaluation of the Kinesis™ ergonomic computer keyboard. Master of Science Thesis, Auburn University, AL.
- Horsford, W.H. (1992). Carpal tunnel syndrome: A review of detection methods and the NIOSH case definition in an industrial environment. *Auburn University Protocol for Research Involving Human Subjects*, Auburn University, AL.

Thomas, Smith, and Horsford

Horsford, W.H., and Thomas, R.E. (1993). A review of carpal tunnel syndrome detection methods. Department of Industrial Engineering, Auburn University, AL. Draft manuscript for the Texas Workers' Compensation Commission.

Kennedy, E.M. (1990). A computer-aided algorithm for the identification of thermal histograms which represent asymptomatic hands. Master of Science Thesis, Auburn University, AL.

McAtamney, L., and Corlett, E.H. (1993). RULA: A survey method for the investigation of work-related upper limb disorders. *Applied Ergonomics*, 24(2), pp. 91-99.

Merritt, T.W. (1987). An evaluation of infrared thermography for use in a carpal tunnel syndrome control program. Doctoral Dissertation, Auburn University, AL.

Moore, D.J. (1991). *Manager's Guide to Workplace Ergonomics*. Business and Legal Reports, Inc., Madison, CT.

National Institute for Occupational Safety and Health (NIOSH) (1986). *Proposed National Strategy for the Prevention of Musculoskeletal Injuries*. U.S. Department of Health and Human Services, DHHS [NIOSH] Publication No. 89-129. Cincinnati, OH.

(1992). *A National Strategy for Occupational Musculoskeletal Injuries: Implementation Issues and Research Needs*. U.S. Department of Health and Human Services, DHHS [NIOSH] Publication No. 93-101. Cincinnati, OH.

Putz-Anderson, V. (1988). *Cumulative trauma disorders: A manual for musculoskeletal diseases of the upper limbs*. Taylor & Francis, New York, NY.

Snook, S.H. (1989). Cumulative trauma disorders. Liberty Mutual Insurance Company, Technical Report. Boston, MA.

Thomas, R.E. (1991a). Repetitive motion trauma conference highlights. *Bobbin*, 32(6), pp. 82-83.

(1991b). Report on a multidisciplinary conference (Oct. 23-25, 1991, Auburn University) on control and prevention of cumulative trauma disorders in the textile, apparel, and fiber industries. Department of Industrial Engineering, Auburn University, AL.

Carpal Tunnel Syndrome

(1991c). Report on a multidisciplinary conference (Oct. 23-25, 1991, Auburn University) on control and prevention of cumulative trauma disorders (CTD) or repetitive motion trauma (RMT) in the textile, apparel, and fiber industries. *American Industrial Hygiene Association Journal*, 52(10), p. A562.

Thomas, R.E., Vaidya, S.C., Herrick, R.T., and Congleton, J.J. (1993a). The effects of biofeedback on carpal tunnel syndrome. *Ergonomics*, 36(4), pp. 353-361.

Thomas, R.E., Butterfield, R.K., Hool, J.N., and Herrick, R.T. (1993b). Effects of exercise on carpal tunnel syndrome. *Applied Ergonomics*, 24(2), pp. 101-108.

U.S. Department of Labor, Bureau of Labor Statistics (1993). BLS reports on survey of occupational injuries and illnesses in 1992. Washington, DC.

U.S. Public Health Service (USPHS) (1990). Healthy people 2000: National health promotion and disease prevention objectives--occupational safety and health. Washington, DC.

(1992). A public health service progress report on healthy people 2000--occupational safety and health. Washington, DC.

Vaidya, S.C. (1990). The effects of biofeedback on carpal tunnel syndrome. Master of Science Thesis, Auburn University, AL.

Williams, T.L. (1989). Exercise as a prophylactic device against carpal tunnel syndrome. Master of Science Thesis, Auburn University, AL.

Williams, T.L., Smith, L.A., and Herrick, R.T. (1989). Exercise as a prophylactic device against carpal tunnel syndrome. *Proceedings of the Human Factors Society 33rd Annual Meeting*, pp. 723-727.

**PHYSICAL FACTORS AFFECTING THE DISTRIBUTION OF DARTERS
(PISCES: PERCIDAE) IN THE WHITE WATER CREEK WATERSHED
IN SOUTHEAST ALABAMA¹**

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ABSTRACT

During the Spring and Summer of 1993, I examined 20 sites on the White Water Creek Watershed in order to determine how substrate, cover, current velocity, and depth affected the distribution of darters. The data shows that darters are distributed according to the substrate conditions (bedrock, sand, and soft clay or mud), current velocity (high, moderate, slow, no current), and depth (shallow, moderate, deep) present at a given site. A total of 341 darters were sampled at 20 locations. One hundred and forty-nine *P. nigrofasciata* were taken at 12 sample sites and at 7 of the 10 conditions examined. Thirty-one *E. swaini* were taken at 4 sample sites and at 8 of the 10 conditions examined. Forty-eight *E. dawsoni* were taken at 11 of the sample sites and at 9 of the 10 conditions examined. Forty-nine *E. fusiforme* were taken at 6 of the sample sites and was taken at 8 of the 10 conditions examined. Eleven *E. edwini* were taken at 2 of the sample sites and from 3 of the 10 conditions examined. Fifty-three *E. parvipinne* were taken at 9 of the sample sites and at 7 of the 10 conditions examined.

INTRODUCTION

Understanding the habitat requirements of fish has become an important factor in the preservation of aquatic ecosystems as well as threatened species (Ross et al., 1992). Factors affecting the distribution of fish must be examined so that habitat can be preserved and species richness and diversity can be maintained. Studies identifying the influencing factors of fish distribution and habitat requirements are generally lacking for southeastern, nonsalminoid species. These requirements are better documented for cold water northern (Gibson, 1978; Rimmer et al., 1993) and western species (Matthews and Hill 1980; Schlosser, 1982). Darters like many other stream fish are adversely affected by habitat loss and the general decline of stream conditions (Gorman and Karr 1978). Human induced impacts such as impoundments, channelization, point source and non point source pollution greatly affect the energy sources, general water quality, habitat quality, biotic interactions, and flow regime within a given stream. These factors greatly influence the distribution of fish species

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(Karr et al 1986). Because of their sensitivity to stream degradation, darters are usually the first fish to be affected by habitat degradation (Karr et al., 1986). Because of their sensitivity to changes in stream conditions, darters are excellent candidates for study in order to understand how habitat requirements and habitat loss influence fish distribution. Darters are widely distributed throughout the southeastern United States and their distribution and habitat usage are likely influenced by hydraulic conditions, behavior, and tropic responses as are many other species of fish (Meffe and Sheldon 1988; Freeman and Stouder 1989).

STUDY AREA The study area, White Water Creek watershed was chosen because of the wide range of habitats located in this system. White Water Creek is a fourth order stream that runs through Pike and Coffee Counties (Figure 1) in southeast Alabama and drains into the Pea River at Elba, Alabama.

In this study, I examined substrate type, cover, current velocity, and depth at twenty locations in order to determine if these factors affect the distribution of six darter species in the White Water Creek watershed in southeast Alabama. The darter species I examined are *Percina nigrofasciata*, (blackbanded darter), *Etheostoma swaini* (gulf darter), *E. davisoni* (choctawhatchee darter), *E. fusiforme* (swamp darter), *E. Edwini* (brown darter), and *E. parvipinne* (goldstripe darter).

METHODS AND MATERIALS

Darters were collected in late Spring and early Summer of 1993 from 20 locations throughout the watershed (Figure 1). Specimens were collected from smaller stream areas using a D - ring kick net. In locations where the stream width was large, a seine with a 3 mm mesh was used. Specimens were obtained by placing the nets down stream from the sample area and disturbing the surrounding substrate and cover. Sample plots measured 10 m². Captured specimens were identified (Page and Burr 1991) and released.

Sample areas were divided into categories based on substrate type, cover, current velocity, and depth (Table 1). Current velocity was taken by placing a non toxic die into the stream and timing it over a distance of one meter. Current velocity was obtained at each immediate location where a darter was taken. Depth was also recorded at each location where a darter was taken. Parameters for current velocity and depth were obtained from the mean values recorded at each site where a given species was obtained.

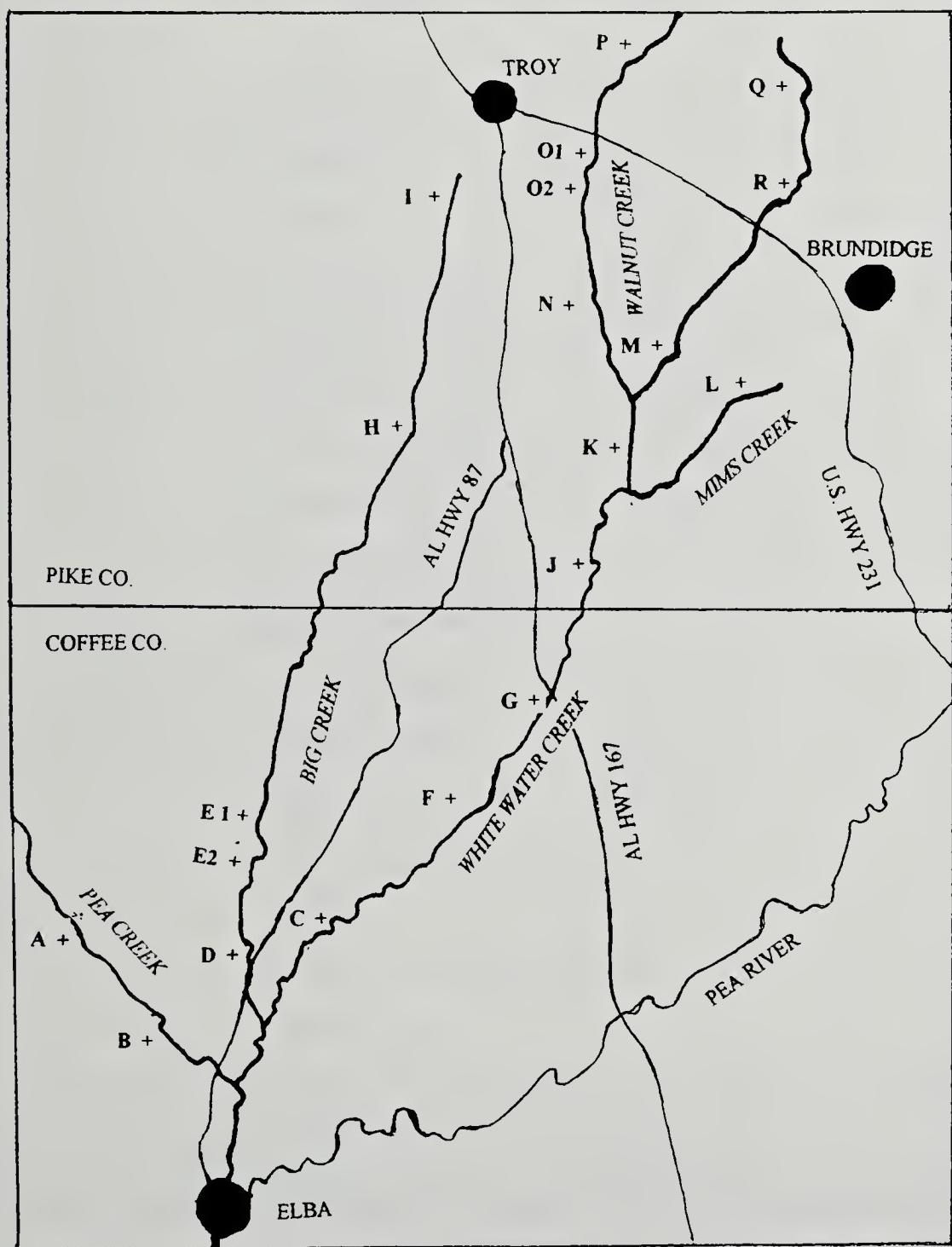
RESULTS AND DISCUSSION

A total of 341 darters were collected at the 20 sample locations. *P. nigrofasciata* was the most abundant species and the most widely distributed species and occurred at 7 of the 10 sample area while *E. edwini* was the least abundant

Physical Factors Affecting the Distribution of Darters

Figure 1.

Map of the White Water Creek watershed which flows through Pike and Coffee Counties, Alabama. Sample locations are denoted by a + and are labeled A through R.



Worsham

Table 1. Number of specimens and conditions at each site. Pn - *Percina nigrofasciata*, Es - *Etheostoma swaini*, Ed - *E. davisoni*, Ef - *E. fusiforme*, Ee - *E. edwini*, Ep - *E. parvipinne*.

SITE	DARTER SPECIES						TOTAL	SITE CONDITIONS
	Pn	Es	Ed	Ef	Ee	Ep		
A	8	0	2	0	0	4	14	2, 4, 8
B	18	2	0	0	0	0	20	1, 4, 8
C	33	21	0	0	9	0	63	1, 4, 8
D	14	0	2	0	0	6	22	2, 4, 8
E1	0	0	12	0	0	0	12	2, 6, 10
E2	23	0	0	0	0	2	25	1, 4, 8
F	6	1	0	0	2	0	9	1, 4, 8
G	9	0	0	0	0	9	18	2, 4, 9
H	0	0	6	12	0	0	18	2, 6, 9
I	0	0	0	7	0	0	7	2, 4, 9
J	6	0	6	0	0	11	23	2, 4, 9
K	0	0	3	0	0	0	3	3, 4, 10
L	0	0	4	13	0	0	17	3, 6, 10
M	0	0	0	3	0	0	3	3, 7, 10
N	3	0	1	0	0	4	7	2, 4, 8
O1	5	0	7	1	0	3	16	2, 4, 8
O2	7	6	0	0	0	0	13	2, 4, 8
P	0	1	4	0	0	1	6	2, 4, 8
Q	0	0	1	13	0	0	14	3, 7, 9
R	17	0	0	0	0	0	30	3, 5, 8
Totals	149	31	48	49	11	341	341	

Refer to Table 2 for conversion of numerical values for site conditions.

Physical Factors Affecting the Distribution of Darters

species and was the species most restricted by the conditions present at a given site (Table 2). The abundance and distribution of *E. dawsoni*, *E. parvipinne*, *E. fusiforme*, and *E. swaini* fell between these two species respectively.

Table 2.

Classification code of site conditions.

SUBSTRATE CONDITIONS

1. Bedrock

2. Sand

3. Mud or Soft Clay

CURRENT VELOCITIES

4. High Current Velocity > 17 cm/s

5. Moderate Current Velocity 17 to 4 cm/s

6. Slow Current Velocity < 4 cm/s

7. No Detectable Current

DEPTH CONDITIONS

8. Shallow Depth > 20 cm

9. Moderate Depth 20 to 46 cm

10. Deep < 46 cm

COVER TYPES

11. Cobble

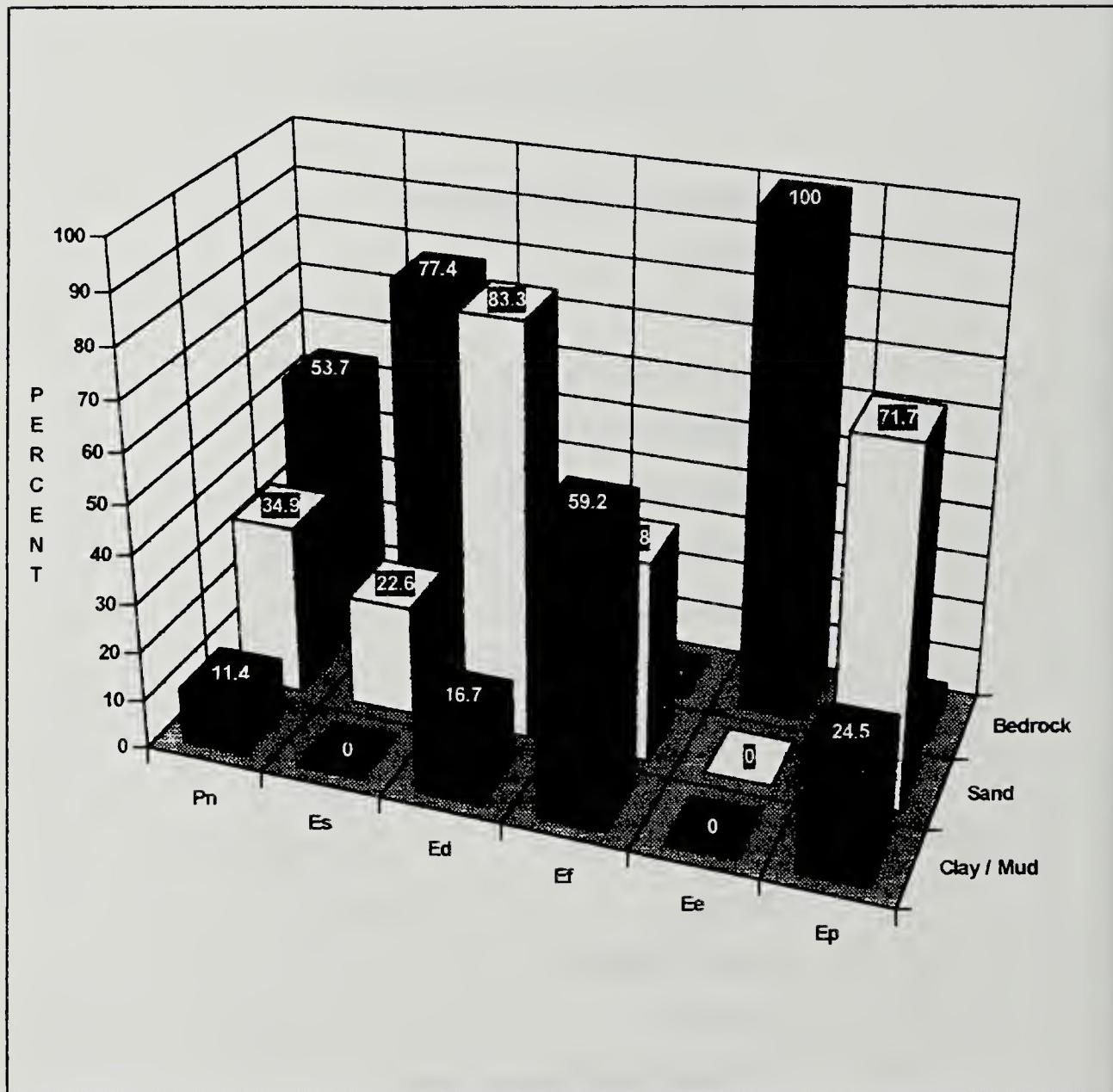
12. Wood Debris (including roots)

13. Macrophytes

The observed data shows that the physical factors examined do affect the distribution of darters. *E. edwini* was the species most restricted to a given substrate type with 100% of this species being taken over a bedrock substrate (Figure 2). It was also present only in conditions where a high current velocity was present and only at a shallow depth (Figures 3 and 4). *E. edwini* was the least abundant of these darters, probably due to the scarcity of bedrock in the White Water Creek watershed. This species was present in only two of the 20 sites samples.

Figure 2.

Percentage of darters at each of the substrate conditions.



Pn - *Percina nigrofasciata*

Ef - *E. fusiforme*

Es - *Etheostoma swaini*

Ee - *E. edwini*

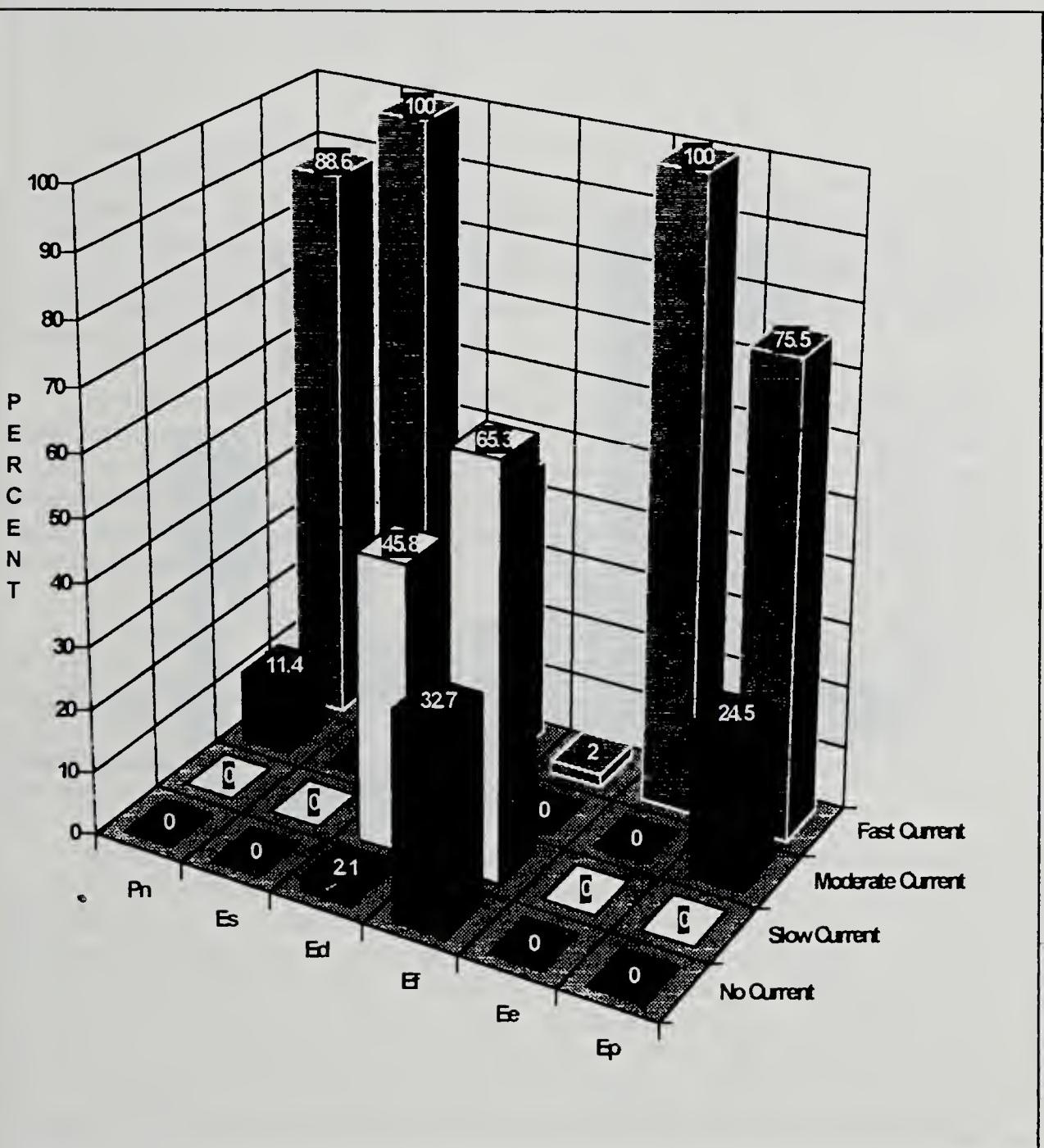
Ed - *E. dawsoni*

Ep - *E. parvipinne*

Physical Factors Affecting the Distribution of Darters

Figure 3.

Percentage of darters found at the varying current velocities.



Pn - *Percina nigrofasciata*

Ef - *E. fusiforme*

Es - *Etheostoma swaini*

Ee - *E. edwini*

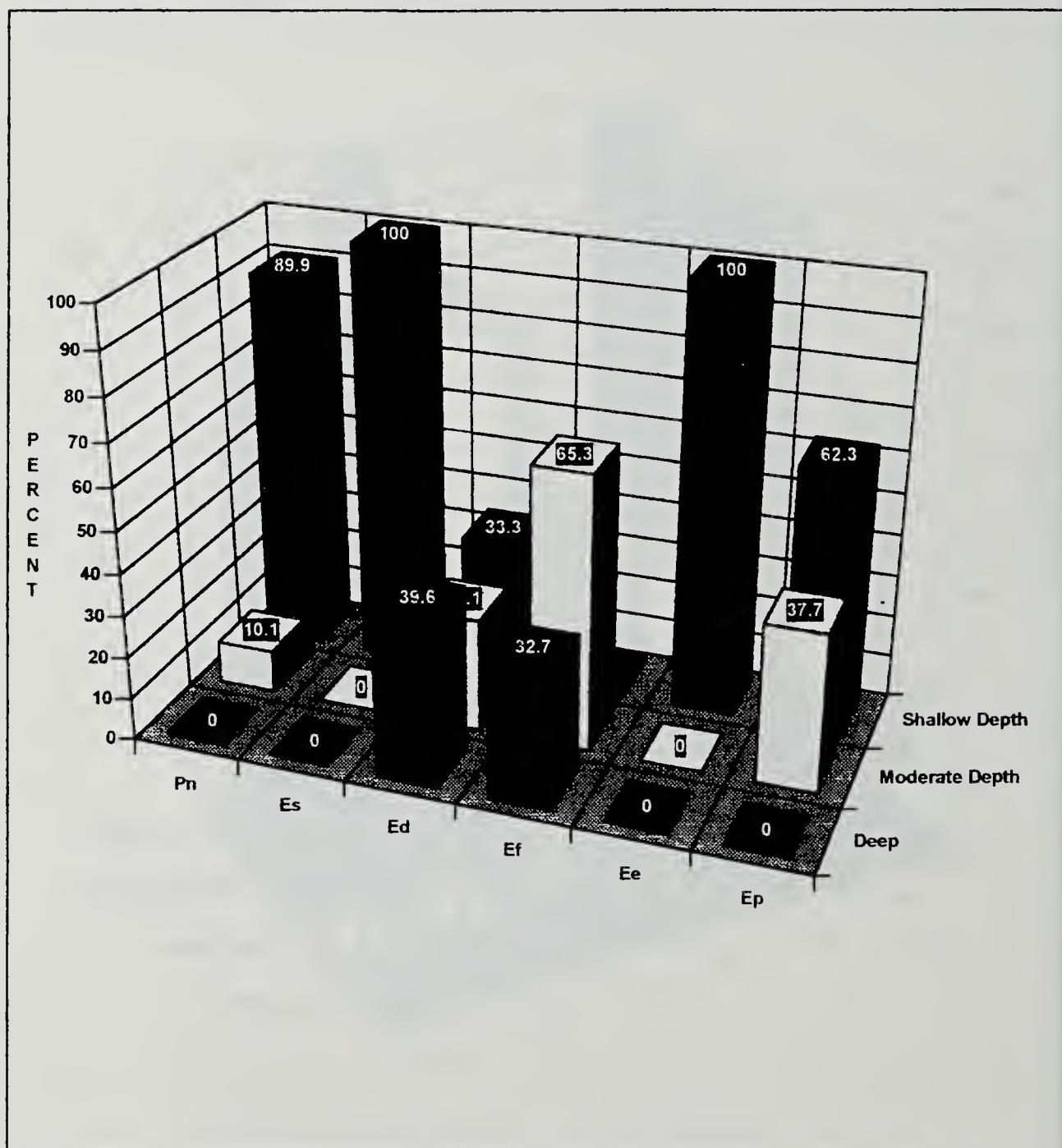
Ed - *E. dawsoni*

Ep - *E. parvipinne*

Worsham

Figure 4.

Percentage of darters found at the three different depth ranges.



Pn - *Percina nigrofasciata*

Ef - *E. fusiforme*

Es - *Etheostoma swaini*

Ee - *E. edwini*

Ed - *E. davisoni*

Ep - *E. parvipinne*

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E. swaini was also largely present over bedrock, with a few (22.6%) taken over sand substrate. This shows that like *E. edwini*, *E. swaini* shows a preference for bedrock substrate. Also affecting the distribution of *E. swaini* is current velocity and depth: 100% of this species was obtained from high current velocity and shallow depths. Because *E. swaini* will tolerate a sand substrate, its distribution is slightly greater than that of *E. edwini* and was located at five of the 20 sample sites.

While the aforementioned species were mainly restricted to a bedrock substrate, *E. dawsoni* was found primarily over sand (83.3%) with a small percentage taken over mud or soft clay (16.7%). Current velocity does not appear to be a factor in the distribution of this species as they were equally abundant in the fast and slow current velocities, and only 8.4% of the specimens were taken from a moderate current velocity or no detectable current. Depth also does not appear to affect the distribution of this species.

E. fusiforme was also found over the same substrate as *E. dawsoni*, but showed a preference for mud or soft clay (58.5%). This is probably due to its preference for swamp or marsh habitat (Page 1982) and was collected in and around beaver impoundments. Current velocities were for the most part slow or negligible, allowing for the deposition of fine substrates. The few specimens (2.0%) from faster waters were found immediately below the beaver dams.

E. parvipinne was distributed by substrate in much the same manner as *E. dawsoni* with the exception of a few occurrences over bedrock. Most specimens (71.7%) were found over sand and mainly in fast currents. A few specimens were taken in moderate current velocities and none at the slower velocities. This species showed a slight preference for shallow depth (62.3%) with the remainder of the specimens being taken from moderate depths.

By far the most widely distributed and most common of the darter species examined is *P. nigrofasciata*. It accounted for nearly half of the darters collected and was taken from 7 of the 10 conditions sampled. While this species was most abundant over bedrock (53.7%) it was also present in relative abundance over sand and was also present over mud or soft clay. While the data show a slight preference for bedrock, other factors such as current velocity and depth probably have more influence on the distribution of this species: 86.6% of this species came from high current velocity, the remaining specimens were taken in moderate current velocity. Similarly, 90% of these darters were taken at shallow depths and the remaining at moderate depths.

The cover types present at each of the sample locations did not affect the distribution of these darter species. It was apparent the presence of cover is important, but the type of cover is not. Examples of this occur frequently in the study. Specimens of *P. nigrofasciata* and *E. swaini* were found in all of the cover

types examined and in equal frequency when all these cover types were examined. Likewise, *E. fusiforme* and *E. dawsoni* were taken from wood debris and macrophytes. In examining if cover is important to these darter species, a χ^2 value of 183.5 was obtained with a critical value of 15.1 ($df=5$, $\alpha=0.01$). This demonstrates that these darters are less abundant in stream areas where cover is absent.

These data clearly show that darters inhabiting the White Water Creek watershed are distributed by one or more of the physical factors examined in this study. These results are also consistent with the previous studies of the habitat of Southeastern fishes (Hackney et al., 1922; page, 1988; Page and Burr, 1911). Seasonal variations in distribution patterns may affect the distribution of this species but determining to what extent will require additional study. This, too, is the case where reproductive strategies are concerned.

Maintaining these physical conditions in this watershed and others is essential for the survival of darter species. While any alteration to current, depth, or substrate will alter the distribution of darters, species such as *E. edwini* would probably disappear from a stream because of the narrow range of conditions they require to survive. Already, this species has become uncommon in the eastern portion of its range (Page and Burr, 1991). This is only one of the many examples that demonstrates the need for the preservation of aquatic habitats which are essential for species survival.

ACKNOWLEDGMENTS

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LITERATURE CITED

- Page, L. M.; Burr, B. M. 1991. *A Field Guide to Fresh Water Fishes*. Houghton Mifflin Company; Boston.
- Freeman, M. C., and Stouder, D. J. 1989. Intraspecific interactions influence size specific depth distribution in *Cottus baridi*. *Environmental Bio. of Fishes*. 24:231-236.
- Gibson, R. J. 1978. The behavior of juvenile Atlantic salmon (*Salmo salar*) and brook trout (*Salvelinus fontinalis*) with regard to temperature and water velocity. *Trans. Am. Fish. Soc.* 107:703-712.

Physical Factors Affecting the Distribution of Darters

- Gorman, O. T., and Karr, J. R. 1978. Habitat structure and stream fish communities. *Ecology*. 59:507-515.
- Hackney, C. T., Adams, S. M., Martin, W. H. (eds.). 1992. *Biodiversity of The Southeastern United States: Aquatic Communities*. New York; John Wiley and Sons, Inc. pp. 233.
- Karr, J. R., Faush, K. D., Angermeier, P. L., Yant, P. R., Schlosser, I. J. 1986. Assessing biological integrity in running waters: A method and its rational. Illinois Natural History Survey Special Publication No. 5.
- Matthews, W. J. and Hill, L. G. 1980. Habitat partitioning in the fish community of a Southwestern river. *Southwest Nat.* 25:51-66.
- Meffe, G. K. and Sheldon, A. L. 1988. The influence of habitat structure on fish assemblage composition in southeastern blackwater streams. *Am. Midland Naturalist*. 120:225-240.
- Page, L. M. 1983. *Handbook of Darters*. T. F. H. publications Inc., New Jersey.
- Page, L. M. and Burr, B. M. 1991. *Peterson Field Guide to Freshwater Fishes*. Boston; Houghton Mifflin Company.
- Rimmer, D. M., Paim, U., and Saunders, R. L. 1983. Autumnal habitat shift of juvenile Atlantic salmon (*Salmo salar*) in a small river. *Canadian J. of Fisheries and Aquatic Sciences*. 40:671-680.
- Ross, S. T. Knight, J. G., and Wilkens, S. D. 1992. Distribution and microhabitat dynamics of the threatened bayou darters, *Etheostoma rubrum*. COPEIA. 658-671.
- Schlosser, I. J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. *Ecol. Monogr.* 52:395-414.

**PREVALENCE OF PHYSICAL ACTIVITY PATTERNS¹
BEHAVIORAL RISK FACTOR SURVEILLANCE SYSTEMS, ALABAMA**

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ABSTRACT

Since 1988, an increasing number of states including Alabama have participated in the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a state-based telephone survey conducted yearly of non-institutionalized adults which utilizes a multi stage cluster design based on a method of random digit dialing. Estimates of the prevalence of physical activity behaviors for the five year period 1988-1992 were obtained using these surveys. The prevalence of Alabamians reporting a sedentary lifestyle increased slightly from 57.8% in 1988 to 60.3% in 1990 before declining to 49.4% by 1992. The prevalence of sedentary lifestyle was inversely related to income and directly related to age. The percentage of Alabamians reporting "no leisure time" physical activity remained relatively stationary fluctuating around 34% over this time period. The percentage of Alabamians performing regular exercise between 1988 and 1992 has increased with the greatest change occurring during the past three years. Between 1990 and 1992 the proportion of Alabamians performing regular exercise increased almost 11%. Implications of these changes are discussed with suggestions for strategies for continued improvement.

INTRODUCTION

Since 1986, an increasing number of states including Alabama have participated in the Behavioral Risk Factor Surveillance System (BRFSS) (27). Currently 45 states plus the District of Columbia participate in the BRFSS. In addition, Alabama is one of 19 states that have established specific priority areas covering the improvement of physical activity of the populace (17). Alabama's goal for the year 2000 is targeted to reduce inactivity and increase the proportion of

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Alabamians who engage regularly in light to moderate activity on a regular basis (1). Specifically the physical activity goal as stated in *Healthy Alabama 2000* is: "to increase the proportion of Alabamians aged 13-18 to 50% and adults aged 18 and over to 30% who engage regularly, preferably daily, in light to moderate activity for at least 30 minutes a day" (1).

An exact determination of progress toward this goal is limited since there has not been an extensive and regular surveillance of physical fitness patterns by Alabamians before 1986. Since 1986 there has been a steady evolution of the types and wording of the Alabama BRFSS survey questions in an attempt to conform to and standardize the questions as found in the national BRFSS surveys (27). Even though there may be some limitations in the standardization and categorization of the questions, the data that are comparable over the past five years can be used to assess trends and progress toward meeting the year 2000 physical activity goal and provide a basis for developing new strategies to address problem areas. The purpose of this paper is to present the most pertinent data from the Alabama BRFSS survey on the progress of physical activity behavior for the five year period between 1988 and 1992.

METHODS

Source of Data

The BRFSS is a state-based telephone monitoring system for estimating health behaviors related to the ten principle causes of premature death in the United States (13). The BRFSS was developed jointly by state health departments and the Center for Disease Control. Non-institutionalized residents with telephones were randomly selected from non-commercial telephone numbers using a multi-stage cluster design based on the Waksberg method of random digit dialing (31). A successful household contact was followed by the random selection of one adult, aged 18 or older, who was interviewed immediately or during a convenient follow-up call. Three interviews were completed per cluster of 100 numbers. The results presented in this paper represent data that was collected on 1,500 persons in 1988; 1,805 in 1989; 2,140 in 1990; 1,966 in 1991 and 2,160 persons in 1992.

Measurement of Physical Activity

The BRFSS survey is designed to elicit information on up to two leisure time physical activities performed most often within the past month. The questions probe for the type of activity performed as well as the average number of times (frequency) per week or month that the activity was performed, and the number of hours or minutes (duration) usually spent in the given activity. In addition, when the respondent reported walking, running, jogging, or swimming, the usual distance covered was estimated in order to determine velocity by dividing the distance by the duration. Based on this information, respondents were classified into four patterns of physical activity participation based on the following scoring methods developed by Caspersen et al. (5):

Physical Activity Patterns

- 1) inactive - no reported leisure time activity;
- 2) irregularly active - the duration and frequency of the reported activities were less than 20 minutes per session, less than three times per week, or both;
- 3) regularly active/not intense - the activities were performed for 20 minutes or more per session, three or more times per week, but the requirement of 60% of cardiorespiratory capacity, or the requirement of dynamic use of large muscle groups, or both, were not met; and
- 4) regularly active/intense - the activities were performed 20 minutes or more per session, three or more times per week, and both the requirement of 60% of cardiorespiratory capacity and the requirement of dynamic use of large muscle groups were met.

The intensity requirement for specific activities was estimated on the basis of intensity codes ($3.5 \text{ ml oxygen per kg} \cdot \text{min}^{-1}$) previously described by either Taylor et al. (30) or Folsom et al. (12). Maximal cardiorespiratory capacity was estimated using sex-specific regression equations developed by Jones and Campbell (18). The predicted maximal cardiorespiratory capacity was then multiplied by 0.60 and the estimated intensity of each reported activity was compared with this value in order to assess whether a given activity met the 60% criterion for maximal capacity.

RESULTS

The number of Alabamians 18 and over reporting a sedentary lifestyle (persons that were classified as either inactive or irregular active) increased slightly from 1988 to 1990 but then began to decline (Figure 1). The percentage of persons reporting a sedentary lifestyle increased from 57.8% in 1988 to 60.3% in 1990 before declining to 49.4% by 1992. Whereas the latter trend appears to be promising, it should be noted that the 49.4% prevalence of a sedentary lifestyle reported in 1992 was still 20 percentage points higher than the year 2000 goal established for the state of Alabama (1). These changes in sedentary behavior appear to be age and income specific. For example, the most recent BRFSS data of 1992 (9) reveals that the prevalence of sedentary lifestyle increases steadily with age (Figure 2). For younger respondents (aged 18-34 years) the prevalence was 45%; for persons aged 35-54, 48.4%; and for older respondents aged ≥ 54 years), 52.2%. Men were more sedentary in the younger age group but women were more sedentary in the middle and older age groups. The prevalence of sedentary lifestyle was inversely related to income (Figure 3). Prevalence (56.9%) was highest for the lowest income category ($<\$15,000$) and lowest (35.7%) for persons in the highest income category ($>\$50,000$).

The same positive trend in the prevalence of Alabamians reporting a sedentary lifestyle was not recorded for individuals that performed "no leisure time" activity. Figure 4 shows that the percentage of Alabamians reporting "no leisure time" physical activity remained relatively stationary and fluctuated around 34% for the past five years (9).

*Prevalence of Alabama Respondents
Aged 18+ Reporting a Sedentary Lifestyle*

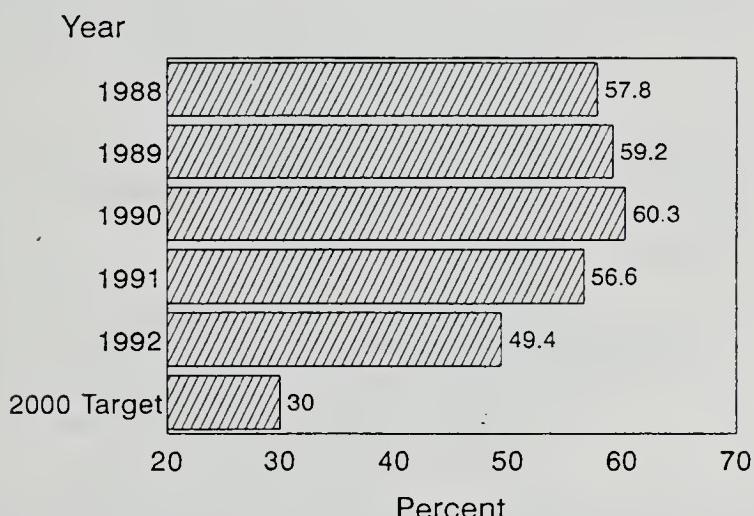


Figure 1. Prevalence of Alabamians ages 18+ Reporting a Sedentary Lifestyle. Data obtained from Centers of Disease Control Behavioral Risk Factor Surveillance System 1988-1992 as conducted by the Alabama Department of Public Health, Bureau of Health Promotion and Information. Montgomery, AL.

*Prevalence of Alabama Respondents in 1992
Reporting a Sedentary Lifestyle by Age*

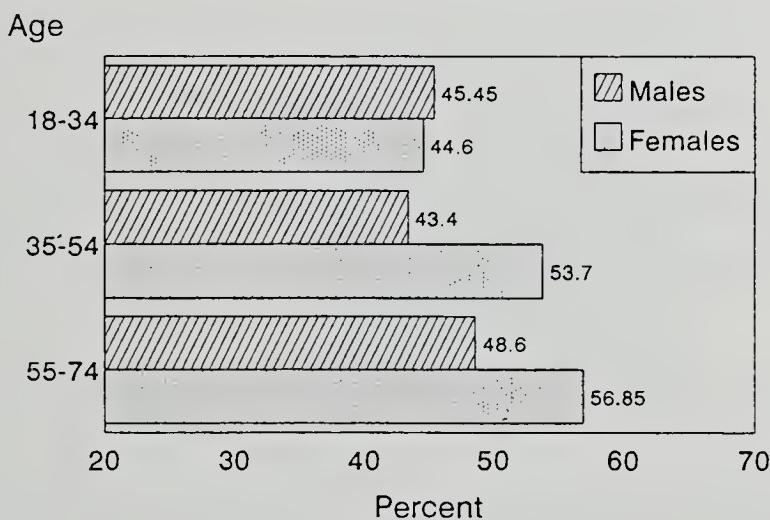


Figure 2. Prevalence of Alabamians Ages 18+ Reporting a Sedentary Lifestyle by Age. Data Obtained from Centers for Disease Control Behavioral Risk Factor Surveillance System 1988-1992 as conducted by the Alabama Department of Public Health, Bureau of Health Promotion and Information. Montgomery, AL.

Physical Activity Patterns

*Prevalence of Alabama Respondents Ages 18+ in 1992
Reporting a Sedentary Lifestyle by Income*

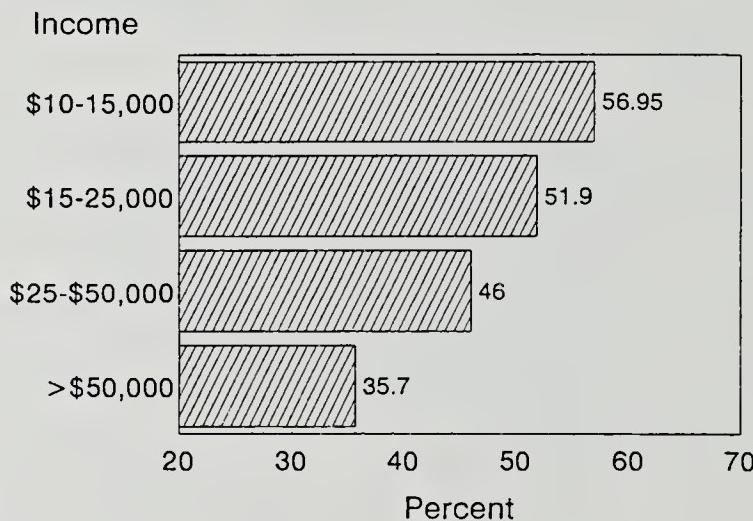


Figure 3. Prevalence of Alabamians Ages 18+ Reporting a Sedentary Lifestyle by Income. Data obtained from Center for Disease Control Behavioral Risk Factor Surveillance System 1988-1992 as conducted by the Alabama Department of Public Health, Bureau of Health Promotion and Information. Montgomery, AL.

*Prevalence of Alabama Respondents Ages 18+
Reporting no Leisure Time Physical Activity*

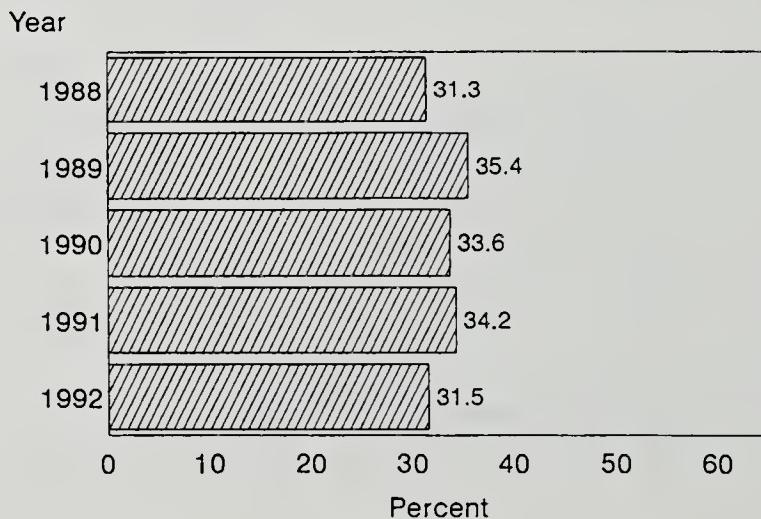


Figure 4. Prevalence of Alabamians Ages 18+ Reporting No Leisure Time Physical Activity. Leisure Activity is defined as no exercise, recreation, or physical activities other than regular job duties. Data obtained from Centers of Disease Control Behavioral Risk Factor Surveillance System 1988-1992 as conducted by the Alabama Department of Public Health, Bureau of Health Promotion and Information. Montgomery, AL.

Figure 5 shows that the prevalence of Alabamians performing regular exercise (activities performed for 20 minutes or more per session, three or more times per week, <60% of cardiorespiratory capacity) has increased steadily over the past five years. In particular, the percentage of Alabamians performing regular exercise during the three year period between 1990 and 1992 has increased sharply from 32.8% in 1990 to 43.3% in 1992.

*Prevalence of Alabama Respondents Ages 18+
Reporting Performance of Regular Exercise*

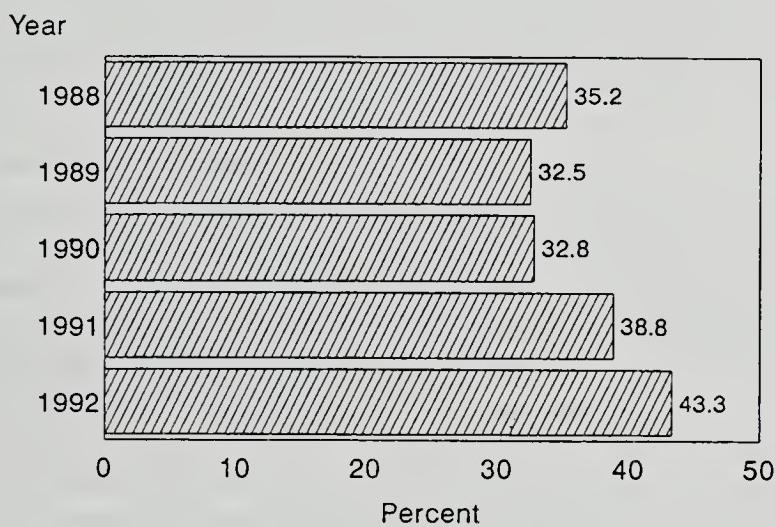


Figure 5. Prevalence of Alabamians Ages 18+ Reporting Regular, Non-intensive Exercise. Regular, non-intensive exercise is defined as activities that are performed for 20 minutes or more per session, three or more times per week, but the requirement of 60 % of cardiorespiratory capacity, or the requirement of dynamic use of large muscle groups, or both, have not been met. Data obtained form Centers for Disease Control Behavioral Risk Factor Surveillance System 1988-1992 as conducted by the Alabama Department of Public Health, Bureau of Helath Promotion and Information. Montgomery, AL.

Determination of trends in Alabamians performing regular virorous activities (activities performed 20 minutes or more per session, three or more times per week at 60% or greater of cardiorespiratory capacity) could not be determined due to newness of the question. However, the latest BRFSS suvey conducted in 1992 revealed that 7.3% of Alabamians reported performing regular vigorous activity.

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DISCUSSION

Since 1953 at least 40 observational epidemiologic studies have assessed the relationship between exercise and coronary heart disease (21). Of these 40 studies, 30 found a protective effect of physical activity, varying in magnitude from 10 - 50% (25). More recently, research methods based on self-reporting have allowed the direct quantification of occupational and leisure-time exercise. These techniques have recently been applied to a series of large-scale prospective studies (4,18,20,23,28), all of which consistently indicate the maintaining a physically active lifestyle is associated with substantial reductions in the incidence of heart disease. A recent review and meta-analysis summarized the impact of physical activity on coronary heart disease by calculating pooled coronary heart disease relative risks for active versus sedentary individuals (2). Among occupation-based cohort studies, the pooled relative risk of inactivity coronary heart disease death was 1.9.

Despite this mounting evidence of the health benefits of physical activity, Alabama like the rest of the United States (5,22,26) remains predominantly a sedentary populace. Whereas some progress has been made during the past five years, nearly one-half of the population remains sedentary and almost one-third reported no leisure-time physical activity. The burden of sedentary lifestyle is becoming more evident (22). For example, data summarized from the 1988 BRFSS (10) indicates that the percentage of coronary heart disease deaths attributable to sedentary lifestyle in the state of Alabama in 1988 was 34% (10). If this risk factor has not been present, it is projected that almost 3000 deaths could have been prevented in this year in Alabama if the population had been more physically active (10).

The surveys conducted between 1988 and 1992 reveal one promising bright spot in that the number of respondents reporting the performance of regular, non-intense exercise has been expanding steadily for the past three years, increasing from 32.8 to 43.3%. This trend in the increase of performance of regular, non-intensive exercise is favorable considering that from an optimal health perspective, increasing physical activity seems to be one of the most advantageous modifications that Alabamians can make in risk reduction and enhancing their overall health (2,3,26). Increasing evidence suggests even though the greatest risk reduction is derived from the performance of regular vigorous activity, light to moderate physical activity, below the level recommended for cardiorespiratory fitness can have significant health benefits (3,24). Even relatively modest increases in activity have been shown to be associated with measurable benefits in persons who have been inactive (14,23). Therefore the relative low 7.3% of Alabamians reporting the performance of regular vigorous exercise is a cause of concern and should be improved, the number of individuals performing regular, non-intense exercise is promising.

The need for increased public health and clinical preventive service efforts to increase physical activity among all sectors of the population is currently well recognized. However, although basic patterns of physical activity in Alabama have

been identified, methods for increasing physical activity are not well understood. It is clear that many dimensions of physical activity must be considered in developing appropriate interventions. These dimensions include awareness of the characteristics of the population (i.e., age, race, ethnicity, gender, education level, socioeconomic status, health status, current physical activity level, the setting (i.e., work place, home), and the activity itself (i.e., type, intensity, frequency, and mode).

In several national surveys and cross-sectional studies in the United States (7,11,29) and Canada (6,29) and Europe (5), researchers report that walking is an activity that is common among all socio-demographic strata. Walking has characteristics associated with weight loss as well as characteristics associated with improvement of physical fitness and maximal adherence (moderate intensity, low perceived exertion, simplicity, convenience, low cost, sociability, and low risk of injury). Therefore, walking may provide the most efficacious technique for improving the physical fitness of Alabamians. Moreover, because of the high prevalence of a sedentary lifestyle in the State's population, the public health impact of such a strategy could be considerable. If the physical activity goal as set forth in *Healthy Alabama 2000* (1) is to be met by the year 2000, continued changes in sedentary lifestyle will have to take place. Accordingly it seems a prudent strategy to meet the goal should be the emphasis on regular rather than vigorous exercise, with the intention of engaging more individuals in a brisk walking program at least three times per week for at least 30 minutes a session.

Although it may be difficult at first to effect a change in the exercise behavior of those who are currently performing no leisure time physical activity, it is important to realize that promotion of a strategy of "conversion" to a more active lifestyle could pay large dividends both to the individual and to society. Motivating people to make an investment of personal time in increased activity such as brisk walking can mean improvement in worker productivity, reduction of worker absenteeism, decrease in demand for medical services, and containment of health care costs.

REFERENCES

- 1) Alabama Department of Public Health. *Health Alabama 2000: Health Promotion & Disease Prevention Objectives for the Year 2000*, Bureau of Health Promotion and Information, Montgomery, AL, October 1991
- 2) Berlin J, Coldiz G: A meta-analysis of physical activity in the prevention of coronary heart disease. *Am J Epidemiol* 132:612-628, 1990
- 3) Blair S, Kohl H, Gordon N, Paffenbarger R: How much physical activity is good for health? *Annu Rev Publ Health*, 13:99-126, 1992

Physical Activity Patterns

- 4) Brunner D, Manelis G, Modan M, Levin S. Physical activity at work and the incidence of myocardial infarction, angina pectoris and death due to ischemic heart disease: an epidemiological study in Israeli collective settlements. *J Chron Dis* 27:217-233, 1974
- 5) Caspersen C, Bloemberg B, Saris W, Merritt R, Kromhout D. The prevalence of selected physical activities and their relation with coronary heart disease risk factors in elderly men: the Zutphen Study. *Am J Epidemiol* 133:1-5, 1991
- 6) Canada Fitness Survey: Fitness and lifestyle in Canada. Ottawa, Canada Fitness Survey, 1983
- 7) Caspersen C, DiPietro L. National estimates of physical activity among older adults. *Med Sci Sports Exerc* 23:S106, 1991
- 8) Caspersen C, Pollard R, Pratt S. Scoring physical activity data with special consideration for elderly population. In Proceedings of the 21st National Meeting of the Public Health Conference on Records and Statistics: Data for the Aging Population, 13-15 July 1987. Hyattsville, Maryland: US Department of Health and Human Services
- 9) Centers for Disease Control Behavioral Risk Factor Surveillance System 1992 as conducted by the Alabama Department of Public Health, Bureau of Health Promotion and Information. Montgomery, AL 1992
- 10) Centers for Disease Control. Coronary Heart Disease Attributable to Sedentary Lifestyle-Selected States, 1988. *JAMA* 261:1390-1392, 1990
- 11) DiPietro L, Caspersen C. National estimates of physical activity among white and black Americans. *Med Sci Sports Exerc* 23:S105, 1991
- 12) Folsom A, Caspersen C, Taylor H, Jacobs D and Luepker R. Leisure-time physical activity and the relationship to coronary risk factors in a population-based sample: The Minnesota Heart Survey. *Am J Epidemiol* 121:570-579, 1985
- 13) Gentry E, Kalsbeck W, Hogelin G, Jones J, Gaines K. The Behavioral Risk Factors Survey II. Design, methods, and estimates from the combined state data. *Am J Prev Med* 1:9-14, 1985
- 14) Harlan W, Landis J, Flegal K, Davis C, Miller M: Secular trends in body mass in the United States, 1960-1980. *Am J Epidemiol*, 128:1065-1074, 1988
- 15) Haskell W, Leon A, Caspersen C. Cardiovascular benefits and assessment of physical activity and physical fitness in adults. *Med Sci Sports Exerc* 24:S201-S220, 1992

Francis and Hataway

- 16) *Healthy People 2000: National Health Promotion and Disease Prevention Objectives.* 1990. Washington, DC. Government Printing Office, Washington, DC 20402-9328
- 17) *Healthy People 2000: State Action 1992.* Washington, DC. Government Printing Office, Washington, DC 20402-9328
- 18) Jones J, Campbell E. *Clinical Exercise Testing* Philadelphia, Saunders. 1982
- 19) Kannel W, Sorlie P. Some health benefits of physical activity: the Framingham Study. *Arch Intern Med* 139:857-861, 1979
- 20) Leon A, Connett J, Jacobs D, Raurama R: Leisure-time physical activity levels and risk of coronary heart disease and death: The Multiple risk factor intervention trial. *JAMA* 258:2388-2395, 1987
- 21) Manson J, Tosteson H, Ridker P, Satterfield S. The primary prevention of myocardial infarction. *New Eng J Med* 326:1406-1416, 1992
- 22) McGinnis J: The public health burden of a sedentary lifestyle. *Med Sci Sports Exer.* 25:S196-200, 1992
- 23) Paffenbarger R, Hyde R, Wing A: Physical activity and physical fitness as determinants of health and longevity. *Exercise, Fitness, and Health.* C. Bouchard, Shephard R., Stephens T., Sutton J., McPherson B. (Eds.). Champaign, IL, Human Kinetics Books, 1990
- 24) Powel K, Caspersen C, Koplan J, Ford E.: Physical activity and chronic diseases. *Am J Clin Nutr* 49:999-1006, 1989
- 25) Powel K, Thompson P, Caspersen C, Kendrick J. Physical activity and the incidence of coronary heart disease. *Annu Rev Pub Hlth* 8:253-287, 1987
- 26) Public Health Focus: Physical Activity and the Prevention of Coronary Heart Disease. *MMWR* 42:669-671, 1993
- 27) Siegel P, Brackbill R, Frazier E, Mariolis P, Sanderson L, Waller M. *MMWR CDC Surveill Summ* 40:1-23, 1991
- 28) Slattery J, Jacobs D, Nichaman M. Leisure time physical activity and coronary heart disease death: the US Railroad Study. *Circulation* 79:304-311, 1989
- 29) Stephens T, Jacobs D, White C. A descriptive epidemiological of leisure-time physical activity. *Pub Hlth Rep* 100:147-158, 1985

Physical Activity Patterns

30) Taylor H, Jacobs D, Schucker B, Knudsen J, Lean A, DeBacker G. A questionnaire for the assessment of leisure time physical activities. *J Chron Dis* 31:741-755, 1978

31) Waksburg J. Sampling methods for random digit dialing. *J Am Statistical Assoc* 73:40-46, 1978

BOOK REVIEW

The Citizens' Guide to Geologic Hazards, by Nuhfer, E.B., Proctor, R.J., and Moser, P.H., American Institute of Professional Geologists, 7828 Vance Dr., Suite 103, Arvada CO 80003, (303) 431-0831. Sets of 35 mm slides also available. 134 p., softcover, perfectbound.

This book is aimed at any person who may be involved in deciding on land use, whether it be deciding which apartment to rent, or where to site a \$100 million hospital. In other words, The Citizens' Guide to Geologic Hazards is for everyone, although people with formal geological training will have less to learn than others.

Cutting to the chase, I recommend this book. I do not know the price, but it can't cost a whole lot. Certainly every public library, every city or county planner, and every prospective home buyer should own a copy...and read it! The book would also be a valuable component of any school library, and earth-science teachers should be familiar with all the topics covered. The book covers a lot of ground, and although no subject is examined in great detail, the only major geologic hazard that I can think of that is not discussed is bolide impact. (One could argue that this is an astronomical hazard, not a geological one, although geologists have the best information on the size and frequency distribution of ancient impacts, and therefore the best information pertaining to probabilities of future impacts). The uniformed lay reader can find a succinct summary of problems and solutions for such geologic hazards as radon, coastal erosion, earthquakes, and volcanic eruptions, written in understandable language.

The controversial topic of asbestos is treated in a biased but objective and informative manner. Many people need to read clear discussions like the one in this book! Radon, another somewhat controversial hazard, is well treated, although the authors failed to explain why some people question the dangers from low levels of exposure to radon. The reason is the question of whether there is a critical minimum dose of radiation below which no significant health risks ensue. The U.S. government and many citizens have adopted the assumption, and it is only that, that there is no critical minimum dose: that for all levels of exposure, the biological response to radiation is essentially linear. This may be true but has never been proven. Honest disagreements make dealing with asbestos and radon difficult, but the problems of other geologic hazards are exacerbated mainly by ignorance. This book does an admirable job of dispelling ignorance. Each section includes a list of references and also a list of relevant videos.

One good aspect of this book is its appendices. Addresses are listed for the U.S. Geological Survey and for state surveys. State insurance commissioners are

Review

listed, as well as some national insurance agencies and organizations. These addresses should prove useful to people seeking additinal information.

The book is not without errors. I've already mentioned one. In addition, the authors make the common error of writing the plural of tsunami as tsunamis. The correct plural form of tsunami is tsunami. A number of terms are misused in the book. For the most part, terms with specific definitions are used in too general a way; the opposite mistake is also made. Reference lists have some obvious omissions. At one point it is stated that 20 percent of the Earth's surface is underlain by permafrost. This implies that about two-thirds of the Earth's land surface is underlain by permafrost, an obvious error. Grammatical, spelling, and typographical errors number about 45, suggesting that the book was never properly edited. However, I believe that errors of fact were more thoroughly rooted out.

I would simply add a note of caution, that no one should make major financial decisions based solely on information presented in this book, and I know that the authors, editors, and publishers would heartily agree. Their goal, and I share it, is to help produce a well-educated public, and a single book, no matter how good, cannot achieve this goal all by itself. They've made a good start.

David C. Kopaska-Merkel
Geological Survey of Alabama
P.O. Box O
Tuscaloosa, AL 35486-9780

Note: Paul Moser, the third author on this book, is an Alabama author.

REPORT ON THE GORGAS SCHOLARSHIP COMPETITION, 1994

The forty-fifth Annual Science Talent Search was conducted on Friday, March 18, 1994, at the Annual Meeting of the Alabama Academy of Science held at Troy State University, Troy, AL.

A total of 33 seniors from 20 Alabama high schools entered the Fifty-third Annual Westinghouse Talent Search conducted by Science Clubs of America and administered by Science Service, 1719 "N" Street N.W., Washington, D.C. 20077-6532, 202-785-2255 (Karen Royden, Director).

On the basis of their high school scholastic records and their Westinghouse science project essays, Dr. Charles E. Feazel, Dr. Glynn P. Wheeler, and Dr. Hazlegrove selected 13 of the contestants as Gorgas Finalists.

Eight of the finalists displayed their science projects for questions before a panel of judges and for private interviews. The judges were:

Dr. Glynn P. Wheeler, Sec./Treasurer, Gorgas, Box 19986,
Birmingham, AL 35219-0986

Dr. L. S. Hazlegrove, Chairman of the Judges, Professor of
Chemistry, Executive Director, Alabama Academy of
Sciences, 208 Rockaway Road, Birmingham, AL 35209-6626

Dr. Ken Dillon, Professor of Industrial Hygiene, UAB

Dr. John Lovin, Senior Vice President Emeritus, Torchmark
Corp., Birmingham, AL

Dr. Dave Cole, Professor of Physics, UAT, Director Int. Cen.

Dr. Jerry Hattaway, Professor of Computer Science, TSU

Dr. Pat Rossi, Professor of Mathematics, TSU

Mrs. Harriet Pullen, Professor of Mathematics, TSU

Dr. Charles Chapman, Professor of Biology, TSU

Dr. James Gore, Eminent Scholar in Environmental Science, TSU

Dr. James Dwyer, Professor of Psychology, TSU

Dr. Edward Barnett, Professor of Mathematics, TSU

The following results of the contest were presented by Dr. Glynn P. Wheeler at the joint banquet of the Alabama Academy of Science and the Alabama Junior Academy of Science at Troy State University.

The winner of the first-place tuition grant of \$2500 was

Ms. Brandi Lynette Bonner, P. O. Box 3092, Hueytown, AL 35023. Resource Learning Center. Mary Ann Little - Teacher.

Gorgas Scholarship

First alternate and winner of a \$1500 tuition grant was

(S) Mr. Tivanka Sanjea Desilva, 1712 C Vestawood Court, Birmingham, AL 35216. Vestavia Hills High School. Mrs. Peggy Patterson - Teacher.

Second alternate and winner of a \$1000 tuition grant was

(S) Mr. Kristofer Jack Thiessen, 202 Grove Lane, Athens, AL 35611. Athens High School. Mrs. Annie Ruth Jamar - Teacher.

Third alternate was

(S) Mr. Eric Gardner Delay, Route 4, Box 309-I, Killen, AL 35645. Brooks High School. Vicki Farina - Teacher.

Fourth alternate was

Mr. Geoffrey Robert Smith, 1409 Oak Tree Court, Mobile, AL 36609. Alabama School of Math and Science. Dr. Terry Schwaner - Teacher.

Fifth alternate was

(F) Mr. William Benton Venable, 705 Noble Road, Tallassee, AL 36078. Tallassee High School. Robert E. Hayes - Teacher.

Sixth alternate was

(S) Mr. Kemka Sorni Ogburia, 3303 Barton Avenue, Huntsville, AL 35810. Lee High School. Ida Crawford - Teacher.

Seventh alternate was

(S) Mr. Alex Clanton Poole, Route 2, Box 96, Lexington, AL 35648. Brooks High School. Vicki Farina - Teacher.

Unable to exhibit:

(S) Ms. Rachna Anand Relwani, 2500 Glen Echo Circle, Huntsville, AL 35803. Grissom High School. Richard Drewyor - Teacher.

(S) Mr. David Shau-Hwa Chung, 2560 Dolly Ridge Road, Vestavia Hills, AL 35243. Vestavia Hills High School. Kay Tipton - Teacher.*

(S) Mr. Keshava Belur Dasarathy, 1313 Chandler Road, Huntsville, AL 35801. Huntsville High School. Meryal Smith - Teacher.

Gorgas Scholarship

(S) Mr. Rinku Dhawan, 2900 Steeple Chase Ct., S., Mobile, AL 36695. Murphy High School. Mrs. Wanda Griffis - Teacher.

Mr. Venable won a \$1000 Westinghouse Scholarship.

The rankings were established by a panel of judges consisting of department heads, deans, and professors from many of the leading universities and industries in Alabama.

Winners and finalists in the Gorgas Contests receive offers of tuition scholarships to colleges and universities in Alabama for the study of science. The Gorgas Foundation is named for General William Crawford Gorgas, the Alabama physician who conquered yellow fever in the Panama Canal Zone and later became the Surgeon General of the U.S. Army. The purposes of the Foundation are to promote interest in science and to aid in the education of promising students.

(F) = Finalist for 53rd Westinghouse Science Talent Search
(S) = Semifinalist for 53rd Westinghouse Science Talent Search
(*) = Deceased

Notes

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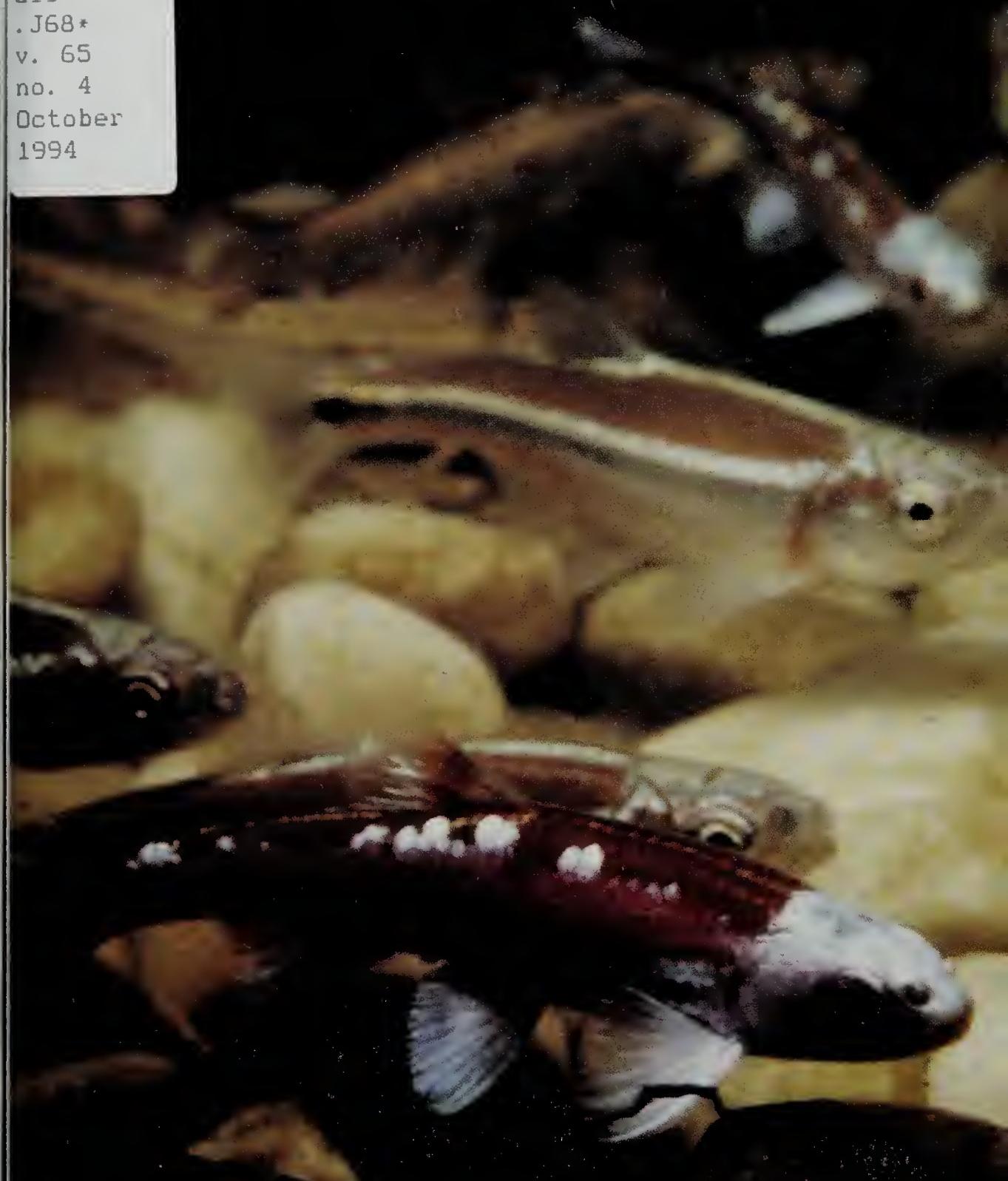
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COVER PHOTOGRAPH: Breeding male rainbow shiner (*Notropis chrosomus*) (foreground) and rough shiner (*Notropis baileyi*) (center) over a bluehead chub (*Nocomis leptocephalus*) nest in Beaver Creek (Alabama River drainage), Alabama.

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REPRODUCTIVE BEHAVIOR OF THE RAINBOW SHINER (*NOTROPIS CHROSOMUS*) AND THE ROUGH SHINER (*NOTROPIS BAILEYI*),
NEST ASSOCIATES OF THE BLUEHEAD CHUB (*NOCOMIS LEPTOCEPHALUS*) (PISCES: CYPRINIDAE) IN THE
ALABAMA RIVER DRAINAGE¹

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ABSTRACT

Reproductive behavior of the rough shiner (*Notropis baileyi*) and rainbow shiner (*Notropis chrosomus*) was observed in two tributaries of the Alabama River in April 1994. Spawning aggregations of rainbow shiners were observed over the pit nests of largescale stonerollers (*Campostoma oligolepis*) and gravel-mound nests of bluehead chubs (*Nocomis leptocephalus*); rough shiners were observed using bluehead chub nests for spawning. Spawning behavior and aspects of reproductive biology are described for rough and rainbow shiners, and the chronology and ecology of nesting associations in the two tributaries are discussed.

INTRODUCTION

Although minnows (Cyprinidae) comprise the largest family of fishes in the world and are the dominant fishes in the streams of eastern North America, very little published information exists on their ecology and life history. Information on reproductive biology is essential for understanding the community ecology of streams and for conserving biodiversity. Of particular interest is an ecologically complex strategy termed nest association, or the habit of spawning in the nest of another species. This spawning strategy is widespread among minnows, which use the nests of other species of minnows or sunfishes and basses (centrarchidae). Including spawning species and their predators, nesting associations may involve almost every species of fish in a stream (Johnston, 1993).

Virtually nothing is known about the biology of the rainbow shiner (*Notropis chrosomus*), a member of the minnow subgenus *Hydroploch* that occurs in the Mobile Bay drainage (Georgia, Alabama and Tennessee) (Page and Burr, 1991). Reproductive biology and food habits have been reported for the rough shiner (*Notropis baileyi*) (Mathur and Ramsey, 1974a,b), also a member of the subgenus

¹Manuscript received 27 August 1994; accepted 21 November 1994.

Hydrophlox. The rough shiner occurs naturally in the Mobile Bay, Pascagoula and Tennessee river drainages and has been introduced in the Chattahoochee River drainage (Gilbert, 1969). Although spawning activities have been observed in the field for the rough shiner (Bart, pers. comm.; Folkerts, pers. comm) no published account of spawning behavior exists for this species. Both rough and rainbow shiners inhabit small, clear streams with sand and gravel substrate, and are syntopic in the lower Mobile Bay drainage, where hybrids have been reported (Swift, 1970). This paper describes the spawning behavior and ecology of rough and rainbow shiners in the Alabama River drainage.

METHODS

Study site

Both Holly Mill and Beaver Creeks are located in Monroe County, Alabama which lies within the Red Hills physiographic region (Mount, 1975). Beaver Creek rises 2.2 km west of the Alabama River, of which it is a direct tributary. It is a clear stream with wooded banks and gravel substrate, and the water averages 2.5 m wide and 40 cm deep. Species present include: least brook lamprey (*Lampetra aepyptera*), largescale stoneroller (*C. oligolepis*), blacktail shiner (*Cyprinella venusta*), striped shiner (*Luxilus chryscephalus*), bluehead chub (*N. leptocephalus*), rough shiner (*N. baileyi*), rainbow shiner (*N. chrosomus*), blacktail redhorse (*Moxostoma poecilurum*), speckled madtom (*Noturus leptacanthus*), longear sunfish (*Lepomis megalotis*), jonny darter (*Etheostoma nigrum*), speckled darter (*Etheostoma stigmaeum*) and blackbanded darter (*Percina nigrofasciata*). Holly Mill Creek is a 4.1 km long tributary of Big Flat Creek, a tributary of the Alabama River. Holly Mill Creek is also a clear stream with wooded banks. The substrate includes gravel, sand lime- or claystone, and the average stream width is 1.5 m. The average water depth is 30 cm. Species present include: largescale stoneroller (*C. oligolepis*), striped shiner (*Luxilus chrysocophalus*), bluehead chub (*N. leptocephalus*), rough shiner (*N. baileyi*), Dixie chub (*Semotilus thoreauianus*), creek chubsucker (*Erimyzon oblongus*), Alabama hog sucker (*Hypentelium etowanum*), blacktail redhorse (*Moxostoma poecilurum*), and longear sunfish (*Lepomis megalotis*).

Field observations

Holly Mill Creek was accessed at a road crossing, T8N, R7E, sec. 7 and checked for spawning activity for a distance of approximately 0.3 km (including upstream and downstream of the bridge). Beaver Creek was accessed at Hwy 41 (T7N, R7E, sec. 24) and checked for approximately 0.5 km (including upstream and downstream of the bridge). The two study streams were checked for nests for three consecutive weeks (Table 1). Three additional sites were checked for nests on two occasions, but none were found (Holly Mill Creek, T8N, R7E, sec. 6 and sec. 16; trib., Big Flat Creek, T8N, R7E, sec. 9).

Reproductive behavior of the rainbow shiner

Table 1. Number of active (spawning aggregations present) and inactive (no fish present) bluehead chub nests present in Holly Mill and Beaver Creeks on sampling dates in 1994.

Date	Number of bluehead chub nests							
	Holly Mill Creek				Beaver Creek			
	active	inactive	total	water temp.	active	inactive	total	water temp.
2-3 April	0	0	0	16° C	0	0	0	16° C
14-16 April	0	1	1	19° C	2	6	8	18° C
29-30 April	4	1	5*	22° C	4	2	6*	22° C

* includes one nest present on 14-16 April, all others new

Observations of fishes were made above the water and underwater by snorkelling. Active nests were observed for 15 - 60 min. periods and checked 2 - 3 times daily. Videos were made above the water and under the surface with an 8 mm video recorder and underwater housing. Videos were later reviewed for verification of spawning behaviors and color descriptions of fishes.

Measurements (height, length, width) of bluehead chub nests were made with a meter stick; water current speed (cm/sec) was measured using a Marsh-McBirney, Inc. model 2000 portable water flowmeter. Collections of fishes were made on 30 April using a seine and preserved in 0.05% buffered formalin. Specimens were later transferred to 70% Ethyl Alcohol.

Laboratory procedures

Specimens of rough and rainbow shiners were examined so that estimates of gonadosomatic index (gonad weight/adjusted body weight X 1000), number of mature ova and length of mature individuals could be made. Individuals were measured to the nearest 0.1 mm with dial calipers. Adjusted body weight (body weight minus internal organs) was taken for air-dried specimens; gonads were also air dried, and both were measured to the nearest 0.0001 gm. Ovaries were classified as ripe, mature or latent (Heins and Baker, 1993). Number of ova in the two largest size classes were counted for five females (both ovaries). Ova diameter was measured to the nearest .01 mm using a dissecting microscope and ocular micrometer and was calculated as the average of two measurements (long and short axis), since the ova were not symmetrical.

RESULTS

One active nest of the Dixie chub was found in Holly Mill Creek on 2 April. One male Dixie chub was briefly observed over a pit-ridge nest, but was frightened

away by the observer and did not return during the observation period. No other fishes were observed over the nest, although the nests of *Semotilus* are often used by other species, including stonerollers (*Campostoma* spp.), striped shiners and creek chubsuckers (Page and Johnston, 1990; Johnston and Page, 1992), which are found in Holly Mill Creek. No other nests or spawning activity was observed in Holly Mill Creek. The red breeding coloration of male rough shiners was slightly developed on large individuals. Females did not release eggs with pressure on the visibly distended abdomens, indicating that they were not quite ready for spawning. No minnow nests or other spawning activity was observed in Beaver Creek. However, cleared depressions at the head of riffles suggested previous spawning activity by stonerollers and blacktail suckers, both known to create these areas during spawning. Dead male stonerollers and one blacktail sucker were found in the stream and may have died from wounds incurred during combat with other males on spawning leks or the energetic stress of spawning, another sign suggesting previous spawning activity by these species. Male rough shiners were slightly red in color; male rainbow shiners had developed breeding colors of iridescent blue heads and lateral stripes down the body with flecks of the same color on the dorsum. The background body color was dull red, and the pectoral, pelvic and anal fins were powder blue.

One inactive (no fishes present) bluehead chub nest was found in Holly Mill Creek on 14 April 1994 (Table 1), and remained inactive on 15 April. Nests and nest-building in *Nocomis* have been described by numerous authors (Reighard, 1943; Raney, 1947; Miller, 1964; Wallin, 1989; Vives, 1990). Finished *Nocomis* nests are large mounds of gravel, but are used for spawning throughout construction, and therefore active nests vary greatly in size (Johnston, 1994).

Eight areas used for spawning by stonerollers and/or blacktail suckers were found in Beaver Creek on 14 April 1994. These areas were all located in shallow (4-10 cm) water at the heads of riffles in gravel substrate. Two of these were active, and had aggregations of largescale stonerollers and rainbow shiners over them. Male largescale stonerollers (15-20) actively defended territories over pits but were continually changing position; no one male held a territory for more than a few minutes. Male rainbow shiners (6-10 individuals) held positions a few cm behind (downstream) stonerollers. No spawning episodes were observed for rainbow shiners in these aggregations.

Eight bluehead chub nests were found in Beaver Creek on 14 April (Table 1); six were inactive and two were active. Both active nests had spawning aggregations of largescale stonerollers (2-12), striped shiners (8-12), rough shiners (10-20), rainbow shiners (6-8) and juvenile or female bluehead chubs (5-10). A male bluehead chub worked on one of the nests. Small numbers of blackbanded darters, Alabama hogsuckers and longear sunfish were present in the nest area. These fishes did not appear to be in spawning condition, and were probably attempting to eat eggs from nests, as described by Vives (1988). Both nests were also active on 15 April. A severe rainstorm occurred on 16 April, and no nests were active.

Reproductive behavior of the rainbow shiner

Five bluehead chub nests were found in Holly Mill Creek on 29 April (Table 1). Active nests had aggregations of largescale stonerollers (4-20) and rough shiners (6-30), but no male bluehead chubs were observed. Four of six nests present in Beaver Creek were active on 29 and 30 April. Numbers of individuals of each species varied depending on the nest.

Many males of both rough and rainbow shiners displayed 'high' breeding coloration on 29 and 30 April, although males in various stages of color development were present over nests. The bodies of breeding male rough shiners were bright red with pronounced gold lateral and dorsal stripes. A gold stripe is also present along the ventral side of the body, and the caudal spot is pronounced. Females did not develop breeding colors. The bodies of 'high' male rainbow shiners were scarlet red with flecks of iridescent powder blue on the dorsum. The head was the same color blue, as were the pectoral, pelvic and anal fins. Dorsal fins and a red medial band and were blue distally. The eyes of males were scarlet red. The gold lateral stripe usually present on this species is present on 'high' breeding males, but less pronounced than on males in lesser stages of breeding color development. Female rainbow shiners had flecks of iridescent powder blue on the dorsum and head, but did not otherwise develop breeding colors.

Males of both rough and rainbow shiners jockeyed for positions over small pits or central positions over nests. The pits were constructed either by male bluehead chubs for their own spawning or by largescale stonerollers. Aggregations were present from the central portion of the nest back to the downstream edge. Males were aggressive, particularly to conspecifics, and chases were common. Males of both species would also butt conspecifics in the side with their heads. On one occasion a single large male rough shiner held a territory over the front (upstream portions) of a nest, driving off all intruders. Several females entered this area, were approached by the male who aligned his body laterally with the female and drove her to the substrate where both briefly vibrated, presumably spawning. The male spawned several times in succession with several females ($n=4$). In other situations, several males fought for access to females entering the nest area, usually the center of the nest. Females were often driven away from the nest by aggressive males. Females spawned with single males ($n=3$) or with two males ($n=2$) (on either side of her body) simultaneously. Females quickly retreated to the area downstream of the nest. Female rainbow shiners remained over nests for long periods of time compared to rough shiners, and were difficult to distinguish from males that were not in peak breeding coloration. When ready to spawn, a female would swim alongside a male, often aligning her body with his. The pair would spawn by swimming into a pit or depression in the nest gravel, dipping towards the substrate and vibrating very rapidly ($n=4$). Females would also spawn with two males simultaneously ($n=1$). Individuals of both species were observed eating 'loose' eggs.

Blackbanded darters were observed holding territories over three bluehead chub nests in Beaver Creek. Individual darters chased conspecifics from the nest

area. One to three individual darters were present in all nest observations. The stomach contents of six blackbanded darters collected near nests were examined for the presence of fish eggs, an indication that the darters were feeding on the eggs from nests. No eggs or fry were found in these stomachs, but all six were full of insects.

Dimensions and water current speed were measured for five bluehead chub nests in Holly Mill ($n=3$) and Beaver ($n=2$) creeks. Mean length (parallel to current) was 66 cm ($SD=17$); mean width 69 cm ($SD=26$); and mean height was 24 cm ($SD=11$). Average current speed beside nests was 22 cm/sec ($SD=6$); on top of nests 25 cm/sec ($SD=6$); in front 22 cm/sec ($SD=3$); and in back 18 cm/sec ($SD=9$) (front, back and beside taken from substrate level).

The number and diameter of ova in the two largest size classes for rough and rainbow shiners is presented in table 2. The mean length of male rough shiners was 40.7 mm standard length (SL) ($SD=6.4$; range=27.6-48.6; $n=24$), and of females was 43.3 mm SL ($SD=6.4$; range=26.8-54.3; $n=21$). Male and female length is not significantly different ($t=1.29$; $p=0.21$). Based on gonad development, male rough shiners below 36.0 mm SL were immature; females below 30.0 mm SL were immature. Male rainbow shiners ranged from 26.8-38.5 mm SL (mean=32.03; $SD=5.0$; $n=6$); females ranged from 23.5-34.6 mm SL (mean=30.4; $SD=4.8$; $n=4$). Males below 28 mm SL were immature; a 23.5 mm SL female was immature. The sample size of rainbow shiners was too small for statistical analysis of data.

Table 2. Number and diameter (average of long and short axis) of ova in the two largest size classes (both ovaries) for rough and rainbow shiners. Ranges in parentheses.

	Mean no. ova	SD	Mean diameter	SD
Rough shiners				
size 1	127.4 (90-161)	27.9	1.29 n=25 (1.14-1.39)	0.07
size 2	121.6 (70-144)	29.5	0.71 n=25 (0.54-1.08)	0.11
Rainbow shiners				
size 1	34.3 (6-69)	31.9	1.02 n=10 (0.75-1.26)	0.20
size 2	64.3 (52-73)	10.9	0.63 n=15 (0.46-0.87)	0.14

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The mean adjusted body weight of male rough shiners was 0.96 gm ($SD=0.48$; range-0.19-1.72), and of females was 1.11 gm ($SD=0.47$; range=0.17-2.24). These values are not significantly different ($t=0.39$; $p=0.70$). The average adjusted body weight of male rainbow shiners was 0.37 gm ($SD=0.19$; range 0.19-0.65) and of females was 0.29 gm ($SD=0.11$; range=0.13-0.41).

The gonadosomatic index (GSI) for male rough shiners ranged from 1.63-23.30 (mean=11.30; $SD=7.13$) and for females ranged from 1.74-154.90 (mean=88.60; $SD=44.30$). These values are significantly different ($t=8.11$, $p=0.0001$). The GSI of male rainbow shiners ranged from 0.44-16.10 (mean=0.65; $SD=6.56$) and for females ranged from 5.50-157.00 (mean=62.10; $SD=65.80$).

DISCUSSION

Spawning behavior in *N. baileyi* and *N. chrosomus* is similar to other species of *Hydrophlox*, which are all nest associates (Johnston, 1991; Johnston and Page, 1992). Typically, aggregations of male *Hydropholox* form over the nests of *Campostoma* or *Nocomis* and remain active for several days. Females, which enter nests only to spawn, and do not defend territories, have a much shorter residence time over nests. The bright red breeding coloration of male rough and rainbow shiners is also typical of the subgenus. Species of minnows in other evolutionary lineages which act as nest associates also typically have bright red male breeding coloration.

Nest associates such as rough and rainbow shiners have higher offspring survivorship due to the parental care of the host and may also benefit from reduced adult and offspring predation due to a selfish heard or dilution effect (Johnston, 1994). Hosts in some nesting associations suffer increased egg predation due to nest associates, which either prey directly on the offspring of the host (Fletcher, 1993) or create a situation that allows other species to do so (Baba, et al., 1990). In other situations hosts benefit from the presence of nest associates via egg predator dilution (Johnston, in press).

The nest associate strategy of these species is a probable explanation for the hybrid *N. baileyi* X *N. chrosomus* that have been reported (Swift, 1970). Hybrids of numerous nest associate species have been reported (Raney, 1940) and are presumably formed during the simultaneous spawning of numerous species over nests.

Coburn (1986) reported the mean ova diameter of rough shiners as 1.15 mm, as calculated from Mathur and Ramsey's (1974a) egg diameter frequency data. This measurement is comparable to our estimate of 1.29 mm, but does differ. Mean ova diameter was 1.02 mm for rainbow shiners. Comparisons of ova counts and measurements across studies are difficult due to discrepancies in the terminology of ova stage and differences in the measurement of unsymmetrical ova. Several size

classes of ova were present in the ovaries of both rough and rainbow shiners, suggesting that females spawn several times a season. This strategy is typical for many species of small fishes, and has been demonstrated for several species (Gale, 1986; Weddle and Burr, 1991). Our counts of ova suggest that batch fecundity (the number of ova in one size class, in this case the next largest found in the ovary) is 122 for rough shiners and 64 for rainbow shiners. Mathur and Ramsey's (1974a) data suggest a batch fecundity of 130-140 (estimated from data presented in a regression analysis) for rough shiners.

The data for GSI in rough shiners reflect the typical pattern in fishes of high investment by females in ova production, compared to the investment by male in testes. Males of many species use resources for somatic growth, and are larger than females at maturity. Males are often territorial, and larger males may be the best competitors for resources, territories and females. The energy males do not put into gonadal tissue (assuming males and females invest equally in reproductive effort) apparently is not used for somatic growth in rough shiners; male and female standard length do not differ. Furthermore, males are not heavier than females at this point in the breeding season (the specimens were collected on 30 April 1994). It is possible that males produce sperm at a much higher rate than females (Baylis, 1981) and that this investment is not reflected in testes weight at any given time because sperm are constantly being used, not stored. Males may invest all available resources in spawning and die at the end of the spawning season. Meffe, et al. (1988) reported a die off of male yellowfin shiners (*Notropis (Hydroploch) lutipinnis*), also nest associates of bluehead chubs, at the end of the breeding season. Dead males had lost considerable weight compared to females and living males. The relative investment in reproduction by males and females is poorly understood in these fishes and may offer insight into the evolution of reproductive strategies in minnows and community ecology of streams.

The spawning descriptions and insight into the ecology of these species contributes to an understanding of nest association, the community ecology of streams with nesting associations and the life histories of these poorly known species. Hopefully such information will be used in conservation efforts for these and similar stream communities.

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LITERATURE CITED

- Baba, R., Y. Nagata and S. Yamagishi. 1990. Brood parasitism and egg robbing among three freshwater fish. *Anim. Behav.* 40:776-778.

Reproductive behavior of the rainbow shiner

- Baylis, J. R. 1981. The evolution of parental care in fishes, with reference to Darwin's rule of male sexual selection. *Environ. Biol. Fish.* 6:223-251.
- Coburn, M. M. 1986. Egg diameter variation in Eastern North American minnows (Pisces: Cyprinidae): correlation with vertebral number, habitat and spawning behavior. *Ohio J. Sci.* 86: 110-120.
- Fletcher, D. E. 1993. Nest association of dusky shiner (*Notropis cummingsae*) and redbreast sunfish (*Lepomis auritus*), a potentially parasitic relationship. *Copeia* 1993: 159-167.
- Gale, W. F. 1986. Indeterminate fecundity and spawning behavior of captive red shiners-fractional, crevice spawners. *Trans. Am. Fish. Soc.* 429-437.
- Gilbert, R. J. 1969. The distribution of fishes in the central Chattahoochee River drainage. Master's Thesis, Auburn University, Auburn, Alabama.
- Heins, D. C. and J. A. Baker. 1993. Reproductive biology of the brighteye darter, *Etheostoma lynceum* (Teleostei: Percidae), from the Homochitto River, Mississippi. *Ichthyol. Explor. Freshwaters* 4: 11-20.
- Johnston, C. E. 1991. Spawning activities of *Notropis chlorocephalus*, *Notropis chiliticus*, and *Hybopsis hypsinotus*, nest associates of *Nocomis leptocephalus* in the Southeastern United States, with comments on nest association (Cypriniformes: Cyprinidae). *Brimleyana* 17: 77-88.
- _____. 1993. The evolution and benefits of nest association and other reproductive strategies in North American minnows (Cyprinidae). Ph.D. Dissertation, University of Illinois, Champaign-Urbana. 141 p.
- _____. 1994. The benefit to some minnows of spawning in the nests of other species. *Environ. Biol. Fish.* 40: 213-218.
- _____. In press. Nest association in fishes: evidence for mutualism. *Behav. Ecol. and Sociobiol.*
- _____. and L. M. Page. 1992. The evolution of complex reproductive strategies in North American minnows (Cyprinidae) p. 600-621. IN: R.L. Mayden (ed.). *Systematics, historical ecology, and North American freshwater fishes*. Stanford University Press, Stanford, California.
- Mathur, D. and J. S. Ramsey. 1974a. Reproductive biology of the rough shiner, *Notropis baileyi* in Halawakee Creek, Alabama. *Trans. Am. Fish. Soc.* 103: 88-93.

- _____. and _____. 1947b. Food habits of the rough shiner, *Notropis baileyi* Suttkus and Raney, in Halawakee Creek, Alabama. Am. Midl. Nat. 92: 84-93.
- Meffe, G. K., D. L. Certain and A. L. Sheldon. 1988. Selective mortality of post-spawning yellowfin shiners, *Notropis lutipinnis* (Pisces: Cyprinidae). Copeia 1988: 853-858.
- Miller, R. J. 1964. Behavior and ecology of some North American cyprinid fishes. Am. Midl. Nat. 72: 313-357.
- Mount, R. H. 1975. The reptiles and amphibians of Alabama. Agricultural Experiment Station, Auburn, Alabama.
- Page, L. M. and B. M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. Houghton Mifflin, Boston, MA.
- _____. and C. E. Johnston. 1990. Spawning in the creek chubsucker, *Erimyzon oblongus*, with a review of spawning behaviors in suckers (Catostomidae). Environ. Biol. Fish. 27: 265-272.
- Raney, E. C. 1940. Reproductive activities of a hybrid minnow, *Notropis cornutus* X *Notropis rubellus*. Zoologica Soc. 25: 361-367.
- _____. 1947. *Nocomis* nests used by other breeding cyprinid fishes in Virginia. Zoologica 32: 125-132.
- Reighard, J. 1943. The breeding habits of the river chub, *Nocomis micropogon* (Cope). Pap. Mich. Acad. Sci. 28: 397-423.
- Swift, C. C. 1970. A review of the eastern North American cyprinid fishes of the *Notropis texanus* species group (subgenus *Albumops*), with a definition of the subgenus *Hydrophlox*, and materials for a revision of the subgenus, *Albumops*. Ph.D. Dissertation, Florida State University, Tallahassee, 515 p.
- Vives, S. P. 1988. The reproductive behavior of minnows (pisces: Cyprinidae) in two reproductive guilds. Ph.D Dissertation. University of Wisconsin-Madison. 174 p.
- _____. 1990. Nesting ecology and behavior of hornyhead chub *Nocomis biguttatus*, a keystone species in Allequash Creek, Wisconsin. Am. Midl. Nat. 124: 46-56.
- Wallin, J. E. 1989. Bluehead chub (*Nocomis leptocephalus*) nests used by yellowfin shiners (*Notropis lutipinnis*). Copeia. 1989: 1077-1080.

Reproductive behavior of the rainbow shiner

Weddle, G. K. and B. M. Burr. 1991. Fecundity and the dynamics of multiple spawning in darters: an in-stream study of *Etheostoma rafinesquei*. Copeia 1991: 419-433.

PRINCIPLES OF HISTORICAL GEOLOGY AND STRATIGRAPHY FOR USE IN TEACHING¹

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ABSTRACT

Teaching Historical Geology and Stratigraphy as subjects employing the standard scientific method of investigation requires that students know a basic set of principles. These principles are needed to provide guidance in decision making when students develop or select between competing hypotheses or when they evaluate and interpret previous work presented in textbooks and the geologic literature. In a logical order of progression, fifteen basic principles are presented in this paper.

INTRODUCTION

Historical Geology "addresses itself to Earth's evolution, changes in the distribution of lands and seas, growth and destruction of mountains, succession of plants and animals through time, and chronologic changes in other planets in our solar system" (Levin, 1994). Stratigraphy is the branch of geology that treats the formation, composition, distribution, sequence, and correlation of stratified rocks, sediments, and other layered crustal materials (King, 1992). The two subjects are closely linked in the discipline of geology. Stratigraphy is the fundamental subdiscipline of geology underlying the synthesis of Earth's history that is typically presented in a Historical Geology class. Historical geology is usually taken as an undergraduate course while the student is a freshman or sophomore, and stratigraphy is taken by juniors or seniors in a geoscience major.

Research in stratigraphy follows a predictable pattern that mimics the standard scientific method of investigation. First, data on aerial distribution of rock types and geologic structures are recorded on a topographic base map, and lithologic and paleontologic descriptions of local stratigraphic successions are completed. Second, a geologic map is constructed, and the local stratigraphic successions are physically correlated to show lithologic, paleontologic, and temporal relationships. Finally, the information in the geologic map and stratigraphic correlation are synthesized in order to produce a description of the historical geology of the area (King, 1992). Global synthesis of regional and local research in stratigraphy results in the broad knowledge of Earth's history presented in a Historical Geology class.

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The application of the scientific method to teaching Historical Geology and Stratigraphy should be different in the two courses. In Historical Geology, the scientific method should be integrated into the explanations of how the various aspects of the global synthesis of Earth's history being presented was determined by previous workers. Further, the students should be encouraged to develop and test hypotheses in the laboratory part of the course. In Stratigraphy, the students should learn how to acquire stratigraphic data (e.g., field mapping techniques and local-succession descriptions), make geologic maps and stratigraphic correlations, and synthesize interpretations from field data, maps, and correlations. Therefore, students in Stratigraphy need to learn application of the scientific method in the above activities as well as in the critical evaluation of previous stratigraphic research presented in textbooks and scientific literature.

PRINCIPLES

In order to use the scientific method effectively, students in these two courses should know a basic set of principles to guide their decision making when developing or selecting between competing hypothesis or when evaluating and interpreting previous research. To fill this need, the following is suggested as a unified list of the most important principles to be used by Historical Geology and Stratigraphy students.

Most textbooks present six or seven of these principles in several places within the text. Some of the principles are not stated in textbooks and laboratory manuals, but are inferred. It is suggested that all fifteen principles be presented in unison near the beginning of the course.

The following principles are not all unique to Historical Geology and Stratigraphy (namely Multiple Working Hypotheses, Parsimony, and Actualism). Hence, it is important to stress corollaries or example applications of some principles as noted below. The strictly geologic among these principles were first stated by the founding fathers of geology, including Nicholas Steno (1638-1687), John Strachy (1671-1743), James Hutton (1726-1797), William Smith (1769-1839), Charles Lyell (1797-1875), Johannes Walther (1860-1937), and others (see discussions in Schoch, 1989 and Levin, 1994).

The following principles are presented in a suggested logical order of progression in the two courses considered herein. In order of progression, the principles are arranged so that preceding ones are foundation for those that follow. Further, the progression follows the general pattern of course development from basic to more complex reasoning. Where needed, some corollaries, comments, or examples are given below.

1. *Multiple Working Hypotheses.* If, as a result of a thorough scientific investigation, two or more hypotheses cannot be eliminated in light of all facts, they should be retained and acknowledged as equally likely solutions.

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Corollary: It is important to recognize that some problems in geology (and other similar sciences) have non-unique solutions.

Comment: It is very common for two or more hypotheses to be nearly equally likely explanations to a geologic problem. This is one of the reasons that geology has the character of an "inexact science."

Examples: 1) There may be two or more ways to draw a geologic map yourself or interpret a geologic map constructed by another person. 2) There may be an ambiguity in determining the sequence of geologic events in the history of a geologic cross-section.

2. *Parsimony*. The simplest interpretation, considering all facts, is always the best interpretation.

Corollary: Natural processes have always operated in the most efficient manner, using the least amount of energy and the least work.

Comment: This is a key principle to consider when trying to eliminate untenable hypotheses or when reassessing multiple working hypotheses in light of new facts.

Examples: 1) When constructing a geologic map or drawing a stratigraphic cross-section, the simplest presentation of all data and the simplest interpreted relationships among constituent rock layers results in the best presentation. 2) When determining the sequence of geologic events in a geologic cross-section, the simplest list with the fewest number of steps that accounts for all observations is the best list of geologic events.

3. *Superposition*. In a sequence of layers that have not been overturned, the oldest layer is on the bottom.

Comment: This parsimonious and intuitive principle is key to determination of relative age order and thus sequential earth history.

4. *Initial Horizontality*. Layered materials sedimented in a basin (regardless of scale) initially form a stratum having a horizontal attitude.

Comments: 1) Gravity acts on individual sedimentary grains and viscous masses such that a resultant layer having a horizontal aspect is nearly always formed. A horizontal layer is the lowest potential energy position of deposition. 2) The history of any subsequent deformation can be determined from this presumed initial horizontal orientation.

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5. *Cross-cutting Relationships.* A feature that cuts across another is the younger of the two features.

Comment: The application of this parsimonious principle of cross-cutting relationships is not limited to intrusive relations of igneous rocks and brittle deformation structures.

Examples: In stratigraphy, examples include 1) clastic and neptunian dikes, 2) incised fluvial channels, and 3) angular discordances of any scale between strata.

6. *Inclusions.* A layer that contains fragments of another layer or rock is the younger of the two layers.

Comment: This intuitive principle is particularly useful in determining provenance of sedimentary clasts especially when the clastic source is not exposed or no longer exists. Further, it may be useful in determining whether or not erosion is part of the sequence of events in the history of two adjacent rock layers.

7. *Original Lateral Continuity.* Planar strata extend in all directions until they 1) terminate by marginal thinning, 2) abut against an obstruction, or 3) grade laterally into other strata.

Comment: This observation-based principle is the fundamental assumption in all types of physical correlation among individual, described stratigraphic successions.

8. *Facies (or Paleoenvironmental) Succession.* Local facies (i.e., the sedimentary deposits of a paleoenvironment) which develop laterally adjacent to one another at the same time tend to succeed each other vertically with changes in base level or lateral shifts in sites of deposition during geologic time.

Comment: This observation-based principle is most important in interpretation and prediction of vertical successions of layers deposited by rising and falling relative sea level or by shifting depositional centers, such as delta lobes, alluvial fans, or fluvial systems over geologic time.

Examples: 1) Over a span of geologic time when relative sea level (i.e., base level) was rising, sandy sediments of a beach might be covered by muddy sediments of deeper water. Thus, a sequence of sandstone, followed upward by mudstone or shale would likely result. 2) Over a span of geologic time when a delta lobe shifts laterally, prodeltaic mudstones will be overlain by delta-slope muddy siltstones. Further, delta-platform channel sandstones and interchannel mudstones will prograde over delta-slope deposits. Thus, a three-layer deltaic sequence will be deposited by a shifting depositional center.

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9. *Fossil Succession.* Plant and animal taxa occur in the global geologic record (i.e., the global composite stratigraphic column) in a definite, determinable, and reproducible order according to their relative age.

Corollary: The fossil record documents the progressive record of evolutionary change through geologic time.

Comment: This observation-based principle underlies the development of the geologic time scale of the Earth (except the most ancient part of geologic time which predates the fossil record).

Example: Considering that a geologic System is the set of rocks formed or deposited during a geologic Period, we know by definition that the Devonian System contains only Devonian-age fossils and was deposited during the Devonian Period.

10. *Actualism.* The laws of nature do not change with time.

Corollaries: 1) Study the modern sedimentary environments and their processes is the key to interpretation of ancient sedimentary environments and their processes. 2) Sedimentary processes left their imprint on ancient sediments just as modern processes affect modern sediments. 3) Understanding form, function, and ecology of fossils depends upon the study of modern equivalent or similar living taxa.

Comments: 1) This parsimonious principle is the most important tool we have for interpretation of the geologic past. 2) This principle is not the same as uniformitarianism. Uniformitarianism is an outdated concept that included the notion of gradualism, and should no longer be used (see discussion in Gould, 1965 and Shea, 1982).

Examples: 1) Ancient deltaic deposits have distinctive geometries, internal facies relations, grain sizes and grain-size trends, and sedimentary structures and paleocurrents according to the prevailing coastal conditions, river discharge, and tidal ranges as do the several types of modern active deltas. 2) Wave oscillation in shallow water producing symmetrical ripple marks today show how such sedimentary structures of the stratigraphic record were formed throughout geologic time. 3) Fossil oysters lived in environments of varying salinity as do living, modern oysters.

11. *General Mineral Stability.* A mineral is physically and chemically stable only in its original environment of formation (igneous, sedimentary, or metamorphic).

Corollaries: 1) Physical disintegration and chemical decomposition begin when the mineral is removed from its environment of formation. 2) Diagenesis begins after deposition and includes all chemical changes in sediments resulting from changes in interstitial fluids.

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Comments: 1) This general principle is useful in understanding the broad processes of physical weathering, chemical weathering, and diagenesis of sediments and sedimentary rocks. 2) Specific physical and chemical changes in rocks and sediments have been experimentally reproduced.

Examples: 1) The mineral orthoclase that formed in a cooling lava or magma decomposes to form a new mineral (clay) as a part of the hydration reaction in chemical weathering. 2) The mineral calcite replaces original aragonite in a fossil shell as a result of the displacement of original interstitial sea water by fresh water over geologic time.

12. *Oldest-Toward-Youngest Dip.* In a sequence of dipping layers that have not been overturned, the beds dip from oldest toward youngest.

Comment: This parsimonious principle is relevant to geologic maps in the same way that superposition is relevant to stratigraphic successions and geologic cross-sections. Namely, this is the main principle in determining relative age relationships of adjacent layers.

13. *Unconformable Stratigraphic Relations.* An unconformity distinguishes a significant break in the stratigraphic succession and typically represents an appreciable amount of missing stratigraphic record of geologic history.

Comments: 1) An unconformity is a buried surface of erosion, however, not all buried surfaces of erosion are unconformities. Minor surfaces of erosion representing insignificant breaks in stratigraphic successions (i.e., diastems) abound in the stratigraphic record. 2) Whether or not an appreciable amount of missing stratigraphic record characterizes an apparent unconformable stratigraphic relationship should be determined by studying all available physical, paleontological, and structural data (see discussion in King, 1983).

Examples: Unconformable stratigraphic relationships include angular discordances (angular unconformities), erosional surfaces on igneous or metamorphic rock (nonconformities), and parallel-to-layering erosional surfaces with or without appreciable erosional relief (disconformities).

14. *V-Shaped Map Patterns.* Dipping layers (and their geologic contacts) form V-shaped patterns on geologic maps where they cross stream valleys. The apices of the V-shaped patterns point in the general structural dip direction of the layers.

Comments: 1) This general principle allows a geologic map reader to gain an overview of the geologic structure of an area by observing the general structural-dip attitudes of the layers. 2) Vertically dipping layers (i.e., layers with true 90-

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degree dip) are the only exception to this rule concerning dipping layers. Vertically dipping layers form no V-shaped pattern and continue straight across stream valleys and other terraine.

Examples: 1) Steeply dipping layers form relatively broad, open V-shaped patterns. 2) Gently dipping layers form relatively narrow V-shaped patterns.

15. *Map Patterns for Horizontal Layers.* Geologic map patterns for horizontal layers (i.e., layers with true 0-degree dip) and topographic contour lines (representing terraine intersection with horizontal planes at selected elevations) are everywhere parallel.

Corollary: On geologic map, geologic contacts between horizontal layers do not cross topographic contour lines.

Comments: 1) The geologic contacts between horizontal layers (i.e., the planar tops and bases of horizontal layers), will be parallel to topographic contour lines because, by definition, all points on a horizontal plane have the same elevation. 2) Where geologic contacts between horizontal layers cross stream valleys, they form upstream-directed V-shaped patterns that parallel topographic contour lines. The V-shaped pattern of horizontal layers thus formed is readily distinguishable from V-shaped pattern of any dipping beds that dip in an upstream direction because the geologic contacts between any such dipping layers will not be parallel to topographic contour lines.

CONCLUSIONS

While some of the above principles are very narrow and come are very broad, taken together they form a firm foundation for investigating, hypothesizing, interpreting, applying, and understanding scientific reasoning about geologic data in Historical Geology and Stratigraphy. The study and use these principles is encouraged in both the lecture and laboratory sessions of these courses. Students will benefit from the exercise of asking themselves (and being asked): Which principles did you use?

LITERATURE CITED

- Gould, S.J., 1965, Is uniformitarianism necessary?: American Journal of Science, v. 263, p. 223-228.
- King, D.T., Jr., 1983, Stratigraphic breaks: Compass, v. 59, p. 6-8.
- King, D.T., Jr., 1992, *Stratigraphic basics: A combined textbook and laboratory book*: unpublished manuscript, 149p.

King

Levin, H.L., 1994, *The Earth through time* (4th edition, updated version): New York, Saunders College Publishing, 651 p.

Schoch, R.M., 1989, *Stratigraphy. Principles and Methods*: New York, Van Nostrand Reinhold, 375 p.

Shea, J.H., 1982, Uniformitarianism and sedimentology: *Journal of Sedimentary Petrology*, v. 52, p. 701-702.

FEEDING TRIALS WITH THE DUSKY GOPHER FROG, *RANA CAPITO SEVOSA*, IN A RECIRCULATING WATER SYSTEM AND OTHER ASPECTS OF THEIR CULTURE AS PART OF A "HEADSTARTING" EFFORT¹

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ABSTRACT

Alabama biologists believe that the dusky gopher frog, *Rana capito sevosa*, is threatened within the state. One way to increase its numbers may be to "head-start" the eggs and larvae by raising them in a protected environment. Dusky gopher frog eggs were removed from Nellie Pond in Conecuh National Forest, one of only six known breeding ponds in Alabama, and cultured in a recirculating water system. Hatching behavior was observed. Evaluation of feeding treatments using commercially available diets was conducted over a 91-day period. Water quality in the system was monitored, with oxygen levels and water temperature being measured daily. It was found that the most effective diet was dependent upon the required result: a Spirulina flake diet produced the greatest number of survivors (90.8% survival vs overall mean survival of 69.2%, weight of 0.64g with total length of 43.0 mm vs overall mean weight of 0.84 g and length of 44.0 mm), whereas an algae wafer diet resulted in fewer but larger tadpoles (67.5% survival, weight of 1.27 g with total length of 51.5 mm). Another herbivore flake diet yielded 73.3% survival, 0.63 g weight, and 40.5 mm total length. Survival of tadpoles fed boiled spinach was 45.0%, with weight of 0.81 g and total length of 41.1 mm. Separately, since one cause of this frog's decline may be the introduction of predator species into its breeding ponds, the impact of *Gambusia affinis* (mosquitofish) found in Nellie Pond was evaluated by holding eggs and embryos in an aquarium with captured *Gambusia*. Eggs were ignored, but *Gambusia* were observed "nipping" at embryos, all of which eventually died. Surviving tadpoles from the "headstarting" effort, of a size large enough to escape most predation, were released back into their pond of origin to help increase the local population.

INTRODUCTION

Biologists in Alabama have determined that the dusky gopher frog, *Rana capito sevosa*, is threatened within the state (Means, 1986). Only six breeding ponds

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in Alabama are known, and threats to these breeding ponds continue (Mark Bailey, Alabama Natural Heritage Program, pers. comm.). The best breeding ponds are probably those which dry periodically during non-breeding seasons, restricting predator populations. However, fish and other aquatic predators may be introduced by man and/or by nature. This has occurred at Nellie and Yellow Hill Ponds in Conecuh National Forest. In the case of these two ponds, fish predation is thought responsible for seriously impacting amphibian reproduction for a time (M. Bailey, pers. comm.; Bailey, 1991). These two breeding ponds were lowered by the USDA Forest Service and poisoned with Rotenone on November 3, 1992, to kill the fish present. In both cases, however, *Gambusia affinis* (mosquitofish) were not exterminated. In general, most tadpole mortality may be due to predation (Calef, 1973), because they are sluggish and unprotected by armament (Sukumaran and Kutty, 1979). The present of fish such as *Lepomis macrochirus*, *Notropis lutrensis*, and *Gambusia affinis* may be a significant cause of frog egg and larval mortality (Werschkul and Christensen, 1977; Grubb, 1972). Fish predation, specifically on crawfish frog (*Rana areolata*) eggs and/or tadpoles, was observed (Werschkul and Christensen, 1977). In temporary ponds, invertebrate predation on frog eggs and tadpoles may also be significant. Laboratory studies have indicated predation by the backswimmers *Notonecta indica* and *N. undulata* (Cronin and Travis, 1986), the predaceous diving beetle *Dytiscus verticalis*, dragonfly naiads of *Anax junius*, the giant water bug *Lethocerus americanus*, *Belostoma* spp. (Brodie and Formanowicz, 1983) and dragonfly naiads of *Aeschna interrupta* (Calef, 1973) and *Tramea lacerata* (Travis, Keen, and Juilianna, 1985). In most cases, the extent of mortality by predators was density dependent and size limited, and it was thought that tadpoles generally may outgrow most predation.

Because of the perceived decline in dusky gopher frog populations and numbers, and the impact by predators during aquatic stages, research was conducted on "headstarting" these frogs through their culture from egg to advanced tadpole stage, and subsequent release back into their pond of origin. While it is hoped that some of these larvae may survive to eventually become breeders, this first known effort to accomplish such release in Alabama was designed with several purposes in mind. These purposes include 1.) general evaluation of "headstarting" these frogs by hatching the eggs and culturing embryos to advanced tadpole/young frog stage in a protected environment so they could be released back into a pond at a size sufficient to allow them to escape most predation, 2.) determining whether a recirculating water system was appropriate for culture of these larvae, 3.) finding a convenient and satisfactory commercial feed that would provide acceptable survival and growth, 4.) developing specific culture techniques appropriate for this sub-species, and 5.) observing the hatching, development, and general behavior of this sub-species of frog. Obtaining such general information was required because we could find little in the literature on the development and culture of the dusky gopher frog other than that by Volpe (1957).

Feeding Trials with the Dusky Gopher Frog

MATERIALS AND METHODS

Dusky gopher frog eggs were collected from Nellie Pond, in Conecuh National Forest, on January 23, 1993. One complete egg mass and small portions of three other egg masses were placed in a 3.8-L Ziploc plastic bag filled to 3/4 capacity with pond water. A few of the eggs were in the process of hatching. Also collected were approximately 50 *Gambusia affinis* from Nellie Pond, which were placed in a separate 3.8-L bag. The bags were put in a Styrofoam fish transport box and transported to the University of Montevallo. Upon arrival, the bags were floated separately in two 38-L holding aquaria for 1.3 hours; small amounts of aquarium water were added periodically to the bags to acclimate the eggs. Ten eggs showing no sign of embryonic development were removed from the bag containing the egg masses. The remainder were transferred to one of these aquaria after the acclimation period. Hatching was closely observed, both in the aquarium with a 2X hand lens, and in a water-filled Petri dish with a dissecting microscope.

A 28x28-cm segment of plastic fisheries screen was added to the aquarium on January 26, 1993 to provide a suitable substrate for post-hatching embryo attachment. The aquarium was originally equipped with gravel and an undergravel filter. However, the embryos were small enough to slip into the gravel layer and were difficult to count and observe. During transfer of the embryos from the holding aquarium to the jars of the recirculating water system, the gravel and the undergravel filter were removed and replaced with an airstone and a sponge filter. This aquarium, containing extra newly-hatched embryos, was used as a control for the *Gambusia* observations.

A recirculating water system was used for the feeding trials, in which a 456-L plastic wading pool with a double plastic liner served as a water reservoir. Two submersible pumps sent dechlorinated fresh water up into an overhead water distributing device, from which latex water lines, controlled by flow valves and with glass tubing at the ends, supplied 14, 3.8-L glass jars. The jars were arranged linearly along two sides of a wooden table built over the reservoir pool. Water exited the jars through screened prime-retaining siphons (Braid, 1987) and flowed down collecting troughs into filters layered with floss, activated charcoal, and calcareous gravel, and trickled back into the reservoir. The filters were seeded with Cycle "Bacterial Biological Filter Supplement and Organic Sludge Remover." Flow rate was 200 mL/min through each jar.

To determine if siphoning would harm the embryos, siphon trials were conducted on January 26, 1993, when the embryos were approximately 2.7 days old. Twenty embryos were gently siphoned from the bottom of the aquarium through a 36-cm long glass tube (i.d. 5.5-mm), attached to a 1.5-m length of tygon tubing and draining into a 1-L beaker filled to half-capacity. The embryos were then put into a separate 3.8-L jar of the recirculating water system for observation.

Fifteen newly-hatched embryos were transferred to a Petri dish containing a few drops of water and were measured with a dissecting microscope and dial calipers. Ten of the measured embryos were put in one of the extra 3.8-L jars of the recirculating water system to monitor any effects of handling.

On January 29, 1993, 20 6-day-old larvae were removed from the aquarium for initial feeding-trial measurements. Each was transferred to a glass Petri dish, via a glass tube (i.d. 5.5mm) with sufficient water to keep the larvae from drying, but not enough to allow the larvae to swim. The larvae were measured with dial calipers under a dissecting microscope, snout-to-vent and vent-to-tail. Total length was derived by adding the two measurements. These larvae were then added to the jar containing the 10 larvae from the previous measurement trial for continued monitoring.

The breeding pond from which the eggs were removed contained a large population of *Gambusia*. To assess the extent of predation by *Gambusia* on *Rana capito sevosa* eggs and larvae, approximately 50 *Gambusia* of various sizes captured from Nellie Pond were placed in another 38-L aquarium with 10 newly-hatched embryos and 11 unhatched eggs. The *Gambusia* were not fed.

Six days after hatching, on January 29, 1993, free-swimming larvae were transferred to the remaining 12 jars of the recirculating water system for feeding trials. Transferring involved collecting the larvae from the aquarium with a 30-cm length glass tube (i.d. 5.5mm) and depositing the larvae into a glass beaker until 40 were counted. The larvae were then carefully poured into a 3.8-L jar while flushing the beaker with a rinsing bottle. Stocking of the jars was done by a random sequence. The jars were randomly assigned to receive one of four feeding treatments, with three replications of each treatment. The first group received Aquarian Herbivore Diet (Mardel Laboratories, Inc.), a flake food consisting primarily of wheat flour, fish meal, cod liver oil, corn gluten meal, and peas. The second group received Hikari Tropical Algae Wafers (Kyorin Co., Ltd.), a sinking wafer consisting primarily of white fish meal, wheat flour, wheat germ meal, shrimp meal, and spirulina. The third group received Spirulina Flake (Ocean Star International), a flake food consisting primarily of spirulina, fish meal, vegetable protein concentrate, baby shrimp meal, fish protein concentrate, and egg. The fourth group received a supermarket-brand frozen pre-cooked spinach. The spinach was prepared by placing an appropriate amount into a glass beaker and heating it to boiling in a microwave oven. Larvae were fed every other day beginning February 1, 1993 (approximately 204 hr. after hatching), in amounts commensurate to larval size. Food was generally completely consumed by the following day.

Dead larvae were counted and removed from each jar daily. The total of the number of surviving larvae plus the number of counted dead was to be compared to the number known to have been stocked to ascertain if such mortality counts would provide a reliable estimate of true mortality.

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For the feeding trials, significance of treatment differences for survival and growth of larvae was tested using Duncan's multiple range test (Steel and Torrie, 1960; protection level = 0.05).

Dissolved oxygen levels and water temperature were recorded at the pond site, during transport, and daily during the research period. Oxygen levels and temperatures were measured using a YSI model 51B Oxygen Meter with a YSI 5700 DO Probe. Additional temperature measurements were recorded daily using a maximum/minimum thermometer placed in the reservoir pool of the recirculating water system. Water quality of the system reservoir was tested a minimum of every two weeks, or as additionally required, using a Hach FF-1A water quality test kit. Water quality at Nellie Pond was measured on January 31, 1993 (eight days after collecting the egg masses), and again during release of the tadpoles back into Nellie Pond.

On April 22, 1993, weight and measurement trials were conducted on 14 tadpoles from the embryo siphon trial and 14 tadpoles from the embryo measurement trials. In addition, to ascertain if the handling proved stressful, half of each group was treated with "Catch and Release (Improved Formula)" (Jungle Laboratories Corp.). It was hoped, if handling was stressful, "Catch and Release" would improve survival. The tadpoles were removed from the holding jars by gently pouring each jar's contents into a 10-L plastic bucket. Individual tadpoles were then netted with an aquarium dip net and placed in a wax depression mold, designed to maintain the tadpole in a lateral position to facilitate measurement. Dial calipers and a 2X magnifying lens were used to measure the tadpoles, snout-to-vent and vent-to-tail. Total length was determined by addition of these measurements. Weight was determined using a digital Fisher-Scientific Model S-110 platform scale by first resting the tadpole on a dry paper towel to absorb excess water, then placing the tadpole in a small plastic tray filled with water on the zeroed platform of the scale. The larvae were returned to the jars for observation to determine the effects of such handling.

RESULTS AND DISCUSSION

Collection and Transport of Eggs. The eggs, containing well-developed embryos, were hand-collected and held in the Ziploc bag for approximately 6 hr. A few recently-hatched embryos were attached to the outside of the egg masses, and were also collected. Survival during transport was 100%.

Observation of Hatching. All eggs hatched by the end of the first night. A few were observed hatching shortly after arrival. The embryo "slid" out of the egg, presumably using cilia to exit as described by Volpe (1957). However, also involved was a vigorous wriggling and pushing action which appeared to aid the embryo in hatching. Thus, in contrast to Volpe's observations, muscular movement appeared to assist hatching in some cases. Once hatched, the embryo remained attached to the

egg by a mucus tether (Duellman & Trueb, 1986), originating from the embryo's antero-ventral end, and attached to a dark body within the center of the egg. The egg retained its spherical shape after hatching, and the tether held the embryo close to the outer gelatinous egg covering. Thus, larvae generally were not directly connected to the egg mass by the "V-shaped mucous gland" ("suckers" as described by Volpe). Some embryos were observed attempting to break away, but the connection resulted in the embryo's revolving around the egg as the egg rotated. It appears that the post-hatching positioning of the embryo on the outer gelatinous egg covering is due to the failure of the tether to part until the embryo is strong enough to break free. While tethered, the embryo assumes a characteristic head up-tail down posture, presumably due to the location of the tether and the force of gravity. The tether seems to function to hold the embryos away from the bottom of the pond, where they might otherwise fall prey to bottom-dwelling predators or suffocate in organic debris. In addition, there may be higher oxygen levels closer to the pond surface, and the sun could provide greater warmth, which may hasten development at this critical time. The embryo's dark coloration may enable them to absorb a greater percentage of available heat, and thus develop faster.

Embryos that break free are incapable of sustained swimming, even when startled. They sink to the bottom and lie on their sides, only briefly darting up from the bottom when disturbed. This inactivity probably conceals the embryos, making them less vulnerable to sight-feeding predators such as fish.

By the third day after hatching, most embryos were free of the egg masses. Several were observed hanging from the fisheries netting by a mucus strand, a space clearly visible between the plastic screen and the anterior end of the embryo. This temporary attachment is similar to that observed in *Xenopus* (Thompson and Franks, 1978).

A number of unidentified greenish-brown mites were seen crawling about the outer egg covering while we observed hatching of the eggs under the dissecting microscope. None were seen on embryos.

Survival and Growth. Feeding trials were terminated on April 30, 1993. Of 480 tadpoles stocked, 332 survived, yielding survival of 69.2%. All three of the commercial feeding treatments yielded higher survival than did the spinach diet (Table 1). This is not unexpected as Mohanty and Dash (1986) reported that a mixed plant and animal diet gave best growth for *Rana tigrina* tadpoles. Of the four feeding treatments, the Spirulina Flake diet yielded the highest survival percentage, whereas the Algae Wafer diet resulted in tadpoles with near-average survival. The Herbivore flake diet yielded survival intermediate between the Spirulina Flake and Algae Wafer diets, and the spinach diet produced the lowest survival. The average total length of the newly-hatched embryos was 9.91 mm, the average total length of the larvae when stocked was 15.63 mm, and the average total length of the tadpoles at termination

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Table 1. Survival, weight, and lengths of dusky gopher frog larvae given four feeds.

Feeding Treatment	Survival (%)	Weight (gm)	Length (mm)		
			Snout-Vent	Vent-Tail	Total
Spirulina Flake	90.8 ± 2.20 a	0.64 ± 0.00 b	14.6 ± 0.1 b	28.4 ± 0.4 a, b	43.0 ± 0.6 b
Herbivore Flake	73.3 ± 6.51 a, b	0.63 ± 0.02 b	14.5 ± 0.2 b	26.0 ± 0.1 b	40.5 ± 0.3 b
Algae Wafer	67.5 ± 11.27 a, b	1.27 ± 0.06 a	17.9 ± 0.1 a	33.5 ± 0.1 a	51.5 ± 0.3 a
Spinach	45.0 ± 1.44 b	0.81 ± 0.03 a, b	15.2 ± 0.1 b	25.9 ± 0.2 b	41.1 ± 0.2 b
Overall Mean	69.2 ± 9.5	0.84 ± 0.15	15.6 ± 0.8	28.5 ± 1.8	44.0 ± 2.5

Values are mean ± SEM; n=3 replicates per mean.
 Means followed by the same letter are not significantly different
 (protection level = 5%).

was 44.0 mm. The Algae Wafer diet produced tadpoles with the greatest mass and length, while weights and total lengths of larvae fed the other diets were less (Table 1). It would appear that satisfactory commercial feeds exist for larval culture, and that it is not necessary to mix a special diet, as has been done for bullfrog culture (Lester, 1988). From our results, it seems apparent that the "best" feeding treatment may depend on whether larger numbers of small larvae are acceptable (Spirulina Flake diet), or whether somewhat fewer but larger larvae are desired (Algae Wafer diet). More research is suggested in this area. Although a number of tadpoles attained large size, none had yet developed hind limbs by the end of these feeding trials.

We found considerable variation in growth among individuals within each replicate in all treatments. Some individuals grew very little, and those that died were usually among the smallest in size. Considerable variation in size can be expected among tadpoles from the same egg mass (Mattison, 1987). Quite possibly, differences in developmental rates of cohorts may result in emergence of metamorphic frogs at different times. This has been suggested as a survival mechanism against terrestrial predation (Fitzgerald et al., 1979). An obvious trade-off is that the longer that tadpoles remain in water, the more likely predation by aquatic species would be, unless they can outgrow such predation (Calef, 1973). "Headstarting" efforts in a protected environment may thus be especially beneficial to these slower-growing tadpoles.

Determining mortality by subtracting the number of survivors from the number stocked into each jar versus actual daily mortality counts indicated that the former method is best. In all jars, the number of larvae that actually died was greater than the number of dead larvae removed and counted would indicate. The number of bodies unaccounted for ranged from 20.0% to 90.5%. Thus, daily mortality counts are not particularly useful in quantifying actual mortality since dead larvae are quickly consumed by the others. This scavenging behavior was often observed in our test jars. Consumption of dead larvae and resulting growth may be related to feeds in that, while certain feeds may not result in high survival, higher growth than expected may result from the presence of this animal protein. For example, although mean percentage of dead larvae unaccounted for ranged from 40.0% to 50.7% for all other feeds, mean percentage of dead larvae not found was 74.7% for the spinach treatment. This may reflect the fact that fewer larvae were receiving relatively more food, or because their diet was being supplemented with the protein from the higher number of bodies not recovered.

A large percentage of the tadpoles developed an opaque, irregular white line along the dorsal and ventral fins of the tail, first noticed on February 11, 1993. Under a dissecting microscope, the opaque line appeared to be internal to the fin, and limited to the middle of the fin. On April 13, 1993, four tadpoles (two with the white lines and two without) were removed from the siphon/measurement trials holding jars

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and transported to Auburn University for analysis. Checks by personnel of the Southeastern Cooperative Fish Disease Project for parasites, bacteria, and pathological effects were negative. It is unknown if this condition affected the health of the larvae.

Gambusia Trial. Although *Gambusia* are known predators on the eggs and larvae of several frog species (Grubb, 1972; Werschkul and Christensen, 1977), in our trials, *Gambusia* showed no apparent interest in the eggs, all of which hatched successfully. However, any movement by an embryo attracted instant attention from the *Gambusia*. *Gambusia* were observed to dart at and nip the caudal portion of embryos lying on the bottom of the aquarium. By January 27, two embryos had died but were not consumed. Two additional embryos were missing approximately 15% of their tails, and six more had "bite-sized" portions missing from the dorsal portion of the caudal fin. On January 28, only one embryo was intact; all the others showed clear signs of fish bite. On February 2, five dead embryos were removed from the aquarium, all showing signs of damage. Of those remaining, all were noticeably smaller than embryos in the control aquarium and the stocking jars. By February 9, no larvae could be found in the *Gambusia* aquarium. Mortality in the control aquarium during this time was zero. It is not known if embryos held with the fish died as a direct result of fish harassment, or due to biochemical stress-related factors, or from a combination of these.

Siphon and Measurement Trials. During siphoning, two larvae were eviscated. Otherwise, all remaining siphoned larvae survived the following week, indicating that, unless immediate and obvious mechanical injury resulted, the siphoning process was not harmful. However, due to the delicate nature of the ventral integument, siphoning is generally discouraged.

As all 28 tadpoles survived the extensive handling of the April 22 weight and measurement trials, the Jungle Labs "Catch and Release" formula was of no apparent benefit. These larvae appear to tolerate normal handling associated with weighing and measuring quite well. Thus the formula was not used at the termination of the project.

Water Quality. When eggs were collected, dissolved oxygen readings at two sites in Nellie Pond, at egg level, were 6.3 and 6.7 mg/L. Pond temperature was 14.5°C, and temperature in the bag containing the eggs was 17.0°C by the time the bag was placed in the cooler for transport. For a brief period, a small amount of ice was placed in the cooler until the temperature in the bag dropped to 13.0°C, when the ice was removed. During the remainder of the trip, the temperature in the bag slowly increased to 18.0°C.

Upon arrival at the laboratory, the bag was floated in the receiving aquarium (water temperature in the aquarium was 19.0°C) for 1.3 hr. The oxygen level in the bag was 6.5 mg/L, and 8.8 mg/L in the aquarium.

Average water quality values for Nellie Pond, the recirculating water system, and a sample of 57 Coastal Plains ponds (Arce and Boyd, 1980) are compared in Table 2. Values for Nellie Pond were generally in the ranges described by Arce and Boyd for ponds in the Coastal Plains, which they found typically exhibit low alkalinity, hardness, and chloride concentration. A direct pH test of Nellie Pond water indicated it to be acidic. This is logical considering the low measurements just described as well as the pond's location on a wooded watershed. The high values for alkalinity, hardness, and pH in the recirculating water system are a reflection of the source of the dechlorinated tap water from limestone-rich strata in north-central Alabama, as well as the contributing affect of the marine calcareous gravel in the system filters. Due to the low pH, we determined percentage un-ionized NH₃ in aqueous solution using formulas suggested by Emerson et al. (1975) for Nellie Pond values. For the recirculating water system, table values as calculated by Emerson et al. were used.

Because of the good survival during our study and the apparent ease of tempering eggs and larvae, it would appear that dusky gopher frog larvae may tolerate a wide range of physical and chemical conditions. The specific conditions measured here are thus probably not a limiting factor with respect to the frog's geographical range, at least during its early life history, provided suitable burrows and predator-free breeding ponds are available.

At 2330 hrs on March 12, 1993, a snowstorm resulted in loss of power to the University of Montevallo. At 0002 hrs on March 13, an aerator powered by a 12-V marine battery was connected to the air lines of the recirculating system and run for 10 min. The air line from one jar not used in the feeding trials was removed to check if subsequent aeration was of benefit. At 0045 hrs, dissolved oxygen in two of the 12 jars was 7.2 and 8.0 mg/L, and water temperature was 21.0°C. At 0102 hrs, dissolved oxygen in the two jars was 7.2 and 7.6 mg/L, and the aerator was again run for 10 min, resulting in readings of 7.3 and 7.8 mg/L, respectively. At hourly intervals thereafter, until 0435 hrs, the jars were aerated for 10 min. At 0435 hrs, dissolved oxygen was 6.4 and 6.9 mg/L in these two jars, and water temperature was 20.2°C. In the jar which had received no aeration, dissolved oxygen was 5.6 mg/L. All larvae appeared healthy. At 0620 hrs, the jars were again aerated for 10 min. As all larvae still appeared healthy, the air line was replaced in the jar which had received no aeration up to this point. At 0800 hrs, each jar was flushed with 4 L of fresh water, and at 1010 hrs, the jars were aerated for 10 min. At 1230 hrs, power was restored and normal operation resumed. Mortality during this period was normal, and no subsequent rise in mortality was observed.

On March 30, 1993, water quality checks revealed that the nitrite level in the recirculating water system was greater than 0.50 mg/L. Sixty L of water were removed from the reservoir, and replaced with 60 L of fresh dechlorinated tap water in an attempt to reduce the nitrite levels. No decrease was immediately apparent.

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Table 2. Comparison of average water quality values for Nellie Pond, the recirculating water system, and a sample of Coastal Plains ponds.

	Alkalinity mg/L CaCO ₃	NH ₃ mg/L	CO ₂ mg/L	NO ₂ mg/L	pH	Hardness mg/L CaCO ₃	Cl mg/L
Nellie Pond (Two checks)	13.7	0.0001	7.5	>0.5	5.7	0	18.8
Recirculating Water System (Four checks)	271.9	0.02	25.0	0.7	8.0	345.5	69.0
Average for Coastal Plains Ponds*	13.2	-	-	-	12.9	5.5	

* Arce and Boyd, 1980

Ten cc of "Cycle" were added to each of the two system filters. The scheduled feeding on March 31 was reduced to a light feeding, and fresh charcoal was added to the filters. On April 1, nitrite was 0.45 mg/L; on April 2, nitrite levels had fallen to 0.20 mg/L, and by April 5, nitrite level was zero. Mortality during and subsequent to this period was normal.

Otherwise, dissolved oxygen levels ranged from 8.1 to 9.8 mg/L and temperature ranged from 17.0 to 23.0°C in the reservoir pool during this research. The design of the recirculating water system appeared well suited to this type of research. Water quality was maintained through constant filtration (as long as power was available) and considerable aeration from air lines and trickling back into the reservoir pool. Good water quality, as enhanced by aeration, has been shown to increase rate of growth and metamorphosis of *Rana tigrina* tadpoles (Mohanty and Dash, 1986).

Transport and Stocking into Nellie Pond. On May 2, 1993, the surviving tadpoles from the feeding trials and other holding jars were distributed among four 19.0-L plastic buckets, with tight-fitting lids, for transport back to Nellie Pond. Culture water and tadpoles were carefully poured into each bucket at an approximate density of 90 tadpoles per 11.4 L water (=7.9 tadpoles/L). At departure, water temperature was 22.0°C and dissolved oxygen was 8.3mg/L. When checked en route 1.7 hrs later, temperature was still 22.0°C and dissolved oxygen was 6.2 mg/L. Upon arrival at Nellie Pond in Conecuh National Forest after 3.5 hrs in transit, water temperature was 22.8°C and dissolved oxygen was 6.2 mg/L. Survival was 100%.

Water temperature in the pond was 21.5°C, and dissolved oxygen was 7.2 mg/L. The buckets were floated in the pond, and pond water was slowly added to acclimate the tadpoles. They were released into the pond after 30 min.

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LITERATURE CITED

- Arce, R.G. and C.E. Boyd. 1980. Water chemistry of Alabama ponds. Ala. Agr. Expt. Sta., Auburn Univ. Bull. 522. 34 pp.
- Bailey, M. 1991. The dusky gopher frog in Alabama. J. Ala. Acad. Sci. 62(1): 28-34.
- Braid, M.R. 1987. Prime-retaining siphon for use in intensive culture systems. Prog. Fish-Cult. 49: 236.
- Brodie, E.D., Jr. and D.R. Formanowicz, Jr. 1983. Prey size preference of predators: differential vulnerability of larval anurans. Herpetologica 39(1): 67-75.
- Calef, G.W. 1973. Natural mortality of tadpoles in a population of *Rana aurora*. Ecology 54(4): 741-758.
- Cronin, J.T. and J. Travis. 1986. Size-limited predation on larval *Rana areolata* (Anura: Ranidae) by two species of backswimmer (Insecta: Hemiptera: Notonectidae). Herpetologica 42(2): 171-174.
- Duellman, W.E. and L. Trueb. 1986. Biology of amphibians. McGraw-Hill, Inc., New York. 553 pp.
- Emerson, K., R.C. Russo, R.E. Lund, and R.V. Thurston. 1975. Aqueous ammonia equilibrium calculations: effect of pH and temperature. J. Fish. Res. Board Can. 32: 2379-2383.
- Fitzgerald, K.T., L.J. Guillette, Jr., and D. Duvall. 1979. Notes on birth, development and care of *Gastrotheca riobambae* tadpoles in the laboratory (Amphibia, Anura, Hylidae). J. of Herp. 13(4): 457-460.
- Grubb, J.C. 1972. Differential predation by *Gambusia affinis* on the eggs of seven species of anuran amphibians. Amer. Midl. Natur. 88(1): 102-108.
- Lester, D. 1988. Raising bullfrogs on non-living food. Aquaculture Mag. 14(2): 20-27.
- Mattison, C. 1987. Frogs and toads of the world. Facts on File, Inc., New York. 185 pp.
- Means, D.B. 1986. Dusky gopher frog, *Rana areolata sevosa* Goin and Netting. Pages 30-31 in Mount, R.H. (ed.), Vertebrate Animals of Alabama in Need of Special Attention. Ala. Agr. Expt. Sta., Auburn Univ., 124 pp.

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- Mohanty, S.N. and M.C. Dash. 1986. Effects of diet and aeration on the growth and metamorphosis of *Rana tigrina* tadpoles. *Aquaculture* 51: 89-96.
- Steel, R.G.D. and J.H. Torrie. 1960. Principles and procedures of statistics. McGraw-Hill Book Co., Inc., New York. 481 pp.
- Sukumaran, N. and M.N. Kutty. 1979. Vulnerability of prey to predation by freshwater prawn, *Macrobrachium malcolmsonii*. *Aquaculture* 16: 363-366.
- Thompson, D.E. and R.L. Franks. 1978. *Xenopus* care and culture. Carolina Bio. Supply Co. 15 pp.
- Travis, J., W.H. Keen, and J. Juilianna. 1985. The role of relative body size in a predator-prey relationship between dragonfly naiads and larval anurans. *Oikos* 45: 59-65.
- Werschkul, D.F. and M.T. Christensen. 1977. Differential predation by *Lepomis macrochirus* on the eggs and tadpoles of *Rana*. *Herpetologica* 33(2): 237-241.
- Volpe, E.P. 1957. The early development of *Rana capito sevosa*. *Tulane Studies in Zool.*, 5(9): 207-225.

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COMPARATIVE USE OF FLOODPLAINS BY SWAMP RABBITS¹

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ABSTRACT

Abundances of swamp rabbits (*Sylvilagus aquaticus*) in lower and headwater floodplains, and in floodplains formerly flooded by beaver (*Castor canadensis*) but with no active dams were studied. Five replications of the three habitat types were chosen, and transects to count groups of fecal pellets and for habitat analysis were established at each of the study areas. We found no differences in counts of groups of fecal pellets, indicating that abundance of swamp rabbits did not differ by type of floodplain. However, counts in beaver-impacted floodplains were consistently higher than counts in nonimpacted areas; lack of significant differences probably resulted from low power of test and inadequate replication of floodplain types. Sixty percent of all pellet groups on transects were on the ground as opposed to elevated objects like stumps or logs. If counts of pellet groups are to be used as an index of abundance for populations of swamp rabbits, it is important not to overlook groups of pellets on the ground. Small floodplains in Alabama are important as habitat for swamp rabbits, and failure to consider them when using the habitat-suitability index model could result in undocumented loss of significant blocks of habitat.

INTRODUCTION

The swamp rabbit (*Sylvilagus aquaticus*), along with other *Sylvilagus*, is a significant small-game animal in the United States (Chapman and Feldhamer 1982). It is a representative species of lowland hardwood wetlands (Fredrickson 1978) occurring primarily in swamps, river bottoms, and lowland areas. The most dramatic change occurring in these habitats is their conversion to row crops. Needs of the swamp rabbit are incompatible with agricultural practices that restrict forested habitats to small woodlots and narrow streamside belts. In Missouri only about 4%

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of the original habitat of swamp rabbits remains (Korte and Fredrickson 1977a). Loss of habitat is the major reason for the decline of the swamp rabbit throughout much of its range (Korte and Fredrickson 1977b, Whitaker and Abrell 1986).

Swamp rabbits commonly deposit fecal pellets on or beside elevated objects such as logs and stumps (Lowe 1958, Hunt 1959, Terrel 1972, Heuer and Perry 1976, Korte and Fredrickson 1977b). This behavior identifies the presence of swamp rabbits in winter and spring because of clusters of fecal pellets on logs (Whitaker and Abrell 1986), and counts of fecal pellets have been used as an index to population density (Terrel 1972, Heuer and Perry 1976, Whitaker and Abrell 1986).

Habitat-suitability index models for the swamp rabbit have been developed by the U. S. Fish and Wildlife Service (Allen 1985). The model for forested habitat relies primarily on data obtained at the periphery of the swamp rabbit's range (Toll et al. 1960, Terrel 1972, Korte 1975, Korte and Fredrickson 1977b) where original extensive bottomland forests have been reduced to isolated fragments. Few studies have been conducted within the core of the species' range, and in Alabama in particular, where much of swamp rabbit habitat is distributed along watercourses.

One premise of the habitat-suitability index model for forested habitat of swamp rabbits is that relatively large tracts (100 ha or more) of wetland habitat are required to maintain viable populations of the species. This requirement is based primarily on data from Missouri (Korte 1975) where most remaining bottomland hardwood forest is bordered by cropland. Allen (1985) notes that adjacent habitats may have an important influence on the suitability of a small area of habitat for swamp rabbits because of the potential for displacement during flooding. All of the 67 counties in Alabama are covered with $\geq 26\%$ of timberland; forested area totals > 8.78 million ha (Rudis et al. 1984). Much of the bottomland hardwood is bordered by other forest types of marginal value for swamp rabbits. Smaller floodplains may be important for maintenance of harvestable populations of swamp rabbits. The significance of these floodplains to the swamp rabbit needs to be determined so the HSI model may be applied more accurately and these areas managed more appropriately.

The objectives of this study were to determine: 1) to what extent swamp rabbits use headwater floodplains; 2) if swamp rabbits occurring in headwater floodplains extend their home ranges into adjacent uplands; and 3) to what extent swamp rabbits use floodplains impacted by former flooding by beaver (*Castor canadensis*).

STUDY AREA

The Oakmulgee Ranger District of the Talladega National Forest comprises 62,284 ha (U.S. Forest Service Southern Region 1986) and is located 20 km southeast

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of Tuscaloosa, Alabama. The Oakmulgee Ranger District lies within the Hilly Coastal Plain of Alabama in portions of Bibb, Chilton, Dallas, Hale, Perry, and Tuscaloosa counties.

The topography of the Oakmulgee Ranger District is dominated by ravines along drainages and by narrow ridges and side slopes of adjacent uplands. Three soil associations occur in the drainages (Keys 1983). The Mantachie-Johnston association occurs in wetter floodplains that are subject to more frequent flooding. Mantachie soils occur in the better drained areas of the floodplains, while Johnston soils occur in depressions and low areas (e.g., floodplain pools and old meanders). The sweetbay-tupelo-red maple (*Magnolia virginiana-Nyssa aquatica-Acer rubrum*) community type is prevalent in these floodplains, with sweetbay comprising a majority of the overstory. The Mantachie-Kirkville association is distributed in the more well-drained floodplains, with Mantachie soils in the lower areas and Kirkville soils in better drained areas of the floodplain. These floodplains support a sweetgum-oak-red maple (*Liquidambar styraciflua-Quercus spp.-Acer rubrum*) community type, with sweetgum comprising a majority of the overstory. The Troup-Harleston-Mantachie association occurs in narrow floodplains, with Mantachie soils in the floodplain and Harleston and Troup soils on slopes and terraces. These floodplains support a loblolly pine (*Pinus taeda*)-hardwood community type. Loblolly pine is not dominant, but may comprise as much as 20% of the overstory.

The eastern portion of the Oakmulgee Ranger District is drained by several creeks and small streams that flow into the Cahaba River and Oakmulgee Creek. The western portion is drained by several small tributaries of the Black Warrior River.

METHODS

We examined five replications each of lower floodplain, headwater floodplain and beaver-impacted floodplain. Lower-floodplain study areas extended out from the stream ≥ 100 m. Headwater-floodplain study areas extended 30-100 m. We placed a lower bound of 30 m on width in headwater floodplains to avoid having transects running effectively parallel to the stream. Beaver-impacted floodplains were meadow-like areas previously flooded by beavers with subsequent killing of timber and with no active dams present. These study areas were of varying width (30-100 m) depending upon the extent of impact. We did not survey areas flooded by active beaver dams.

We established transects 500 m long and 6 m wide at each of the study areas. Portions of transects began at the edge of the stream and proceeded perpendicular to the general direction of the watercourse for 100 m or until upland was reached. The next portion of the transect began 60 m downstream for a total length of the transect of 500 m. Transects in beaver-impacted study areas were restricted to

impacted areas of the floodplains. Sections of those transects were separated by some distance <60 m, depending on the size of the impacted area, so that a total length of transect of 500 m would be contained within the areas of impact.

Counts of Groups of Fecal Pellets

We mapped locations of all natural defecation sites (stumps, fallen logs, or other raised objects ≥ 10 cm in diameter) on transects. Any natural defecation sites within 5 m of each other were clumped and counted as 1 site. We checked transects at 30-day intervals four times each during the study. The transects were cleared of all groups of pellets 10 days prior to each check. We recorded locations of all groups of pellets along transects during both clearing operations and transect checks noting whether groups of pellets were on the ground or on an elevated defecation site. The total transect area (500 x 6 m) was constant for all three floodplain types resulting in number of pellet groups per unit area as an index to density of swamp rabbits.

We made a general search for groups of pellets in adjacent uplands. This was a wandering search to check all likely defecation sites along about 3.05-m (10-foot) contour intervals. The search continued upland until groups of pellets were no longer found.

Habitat Analysis

We determined percent closure of tree (woody vegetation > 5 m tall) canopy by the point intercept-spherical densiometer method (Hays et al. 1981). Percent closure of shrub (woody vegetation ≤ 5 m tall) crown and percent cover of herbaceous canopy were determined by the point intercept method. Basal area of trees was measured by prism cruising (Hays et al. 1981).

We took measurements of habitat variables at 25 randomly chosen points along transects in each study area. To eliminate any trampling effect during counts of pellets, points were located 3 m to the right or left (randomly selected) of the transect. For percent closure of shrub crown and percent closure of herbaceous canopy, we stretched tightly a 25-m measuring tape from the sample point on a randomly chosen azimuth not crossing the transect. We placed vertically a bamboo pole 5 m in length at each 1-m interval along the 25 m and steadied it with an attached bubble level. We considered any vegetation touching the pole a "hit"; no more than one hit in the classes of either the shrub crown or herbaceous canopy was recorded per 1-m interval. Percentages at each sampling point were determined by the number of hits out of 25 sampling point intervals along the tape.

Analysis of Data

We used analysis of variance with repeated measures (SAS Proc GLM; SAS Institute 1987) to determine if the mean number of groups of pellets differed among

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the 3 types of floodplains. Data from counts of groups of pellets over time are somewhat analogous to data from a split-plot design (e.g., split plot in space), and the analysis has been referred to as split plot in time (Steel and Torrie 1980: 390).

We included all counts of groups of pellets regardless of whether the period of accumulation of pellets was 20 days (clears) or 10 days (checks) to maximize the number of observations on which to perform statistical analyses. There was no time by treatment effect observed ($P = 0.6233$). The first count of groups of pellets (during the first clearing operation) was excluded from statistical analysis due to the indeterminate period of accumulation of pellets before the study. The result was seven counts of groups of pellets (three clears and four checks) for each study area. Heavy rains on 19 February 1991 and 29 March 1991 caused flooding in many of the study areas, resulting in missing data for nine observations. Therefore 96 of 105 observations were included in the statistical analysis.

We used analysis of variance to determine if means of habitat variables differed according to type of floodplain. Significantly different means ($\alpha = 0.05$) were separated by Tukey's Studentized range test (SAS Institute 1987).

RESULTS

Counts of Groups of Pellets

No groups of pellets were found on transects in the upper study areas of the South Sandy Creek and Affonee Creek drainages. However, groups of pellets were seen on those areas indicating that swamp rabbits were present. Groups of pellets were present on transects in all other study areas.

Counts of groups of pellets did not differ between headwater, lower, and impacted floodplains ($P = 0.392$; Table 1) due primarily to high variability within floodplain types. However, counts of groups of pellets in impacted floodplains were about twice as great as counts in lower floodplains and 2-17 times as great as counts in headwater floodplains. Counts of groups of pellets in lower floodplains ranged 1-6 times higher than those in headwater floodplains. Mean numbers ($\pm SD$) of groups of pellets over the entire study were 14.1 ± 18.0 , 7.4 ± 5.5 and 4.2 ± 6.5 for impacted, lower, and headwater floodplain study areas, respectively. A general decrease in numbers of groups of pellets counted over time occurred for each of the three types of floodplain. Percentages of groups of pellets found on the ground versus on elevated defecation sites ranged from 0 to 90% ($\bar{X} = 45\%$; Table 2).

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Table 1. Mean (\pm SD)^a number of groups of fecal pellets of swamp rabbits for each of three floodplain types at the Oakmulgee Ranger District, Talladega National Forest, during the winter of 1990-1991; $n=5$ except as noted.

Floodplain Type	Date			
	18-21 December ^b	27-31 December	16-20 January	26-30 January
Headwater	10.0 \pm 9.1	2.6 \pm 3.0	8.6 \pm 8.3	6.4 \pm 11.6
Lower	13.8 \pm 7.9	8.8 \pm 7.7	8.0 \pm 7.5	6.8 \pm 5.9
Impacted	25.0 \pm 21.0	15.8 \pm 21.8	17.2 \pm 21.0	13.2 \pm 22.3

Table 1. continued.

Floodplain Type	Date			
	15-19 February	25 Feb-1 March	17-21 March	27-31 March
Headwater	6.0 \pm 7.4	3.6 \pm 4.9	2.0 \pm 2.1	0.8 \pm 0.8
Lower	7.3 \pm 4.0 ^c	5.0 \pm 4.2 ^d	8.0 \pm 4.7	4.5 \pm 2.1 ^d
Impacted	12.6 \pm 11.5	8.8 \pm 12.5	16.8 \pm 25.8	14.0 \pm 18.4 ^e

^aMeans of floodplain types for all periods not significantly different ($P = 0.3921$).

^bFirst sample excluded from statistical analysis due to indeterminate period of pellet accumulation.

^c $n=4$ due to flooding.

^d $n=2$ due to flooding.

^e $n=3$ due to flooding.

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Table 2. Percentage of groups of fecal pellets of swamp rabbits found on the ground for each of 15 study sites at the Oakmulgee Ranger District, Talladega National Forest, during the winter of 1990-1991.^a

Drainage	Floodplain type		
	Headwater	Lower	Impacted
Affonee Creek	- ^b	28	
Blue Girth Creek			0
Elliot's Creek	59	59	8
Fivemile Creek	31	53	90
Ragland Branch	71	42	62
South Sandy Creek	- ^b	86	0

^aFirst sample period excluded from analysis due to indeterminate period of pellet accumulation.

^bNo pellet groups found on study area transects.

Habitat Variables

Study areas on impacted floodplains had a greater percentage of closure of herbaceous canopy than study areas in headwater or lower floodplains ($P < 0.05$; Table 3), but smaller values for all other habitat variables ($P < 0.05$). Study areas in headwater and lower floodplains did not differ for any habitat variables ($P > 0.05$).

DISCUSSION

Analysis of variance indicated that no difference existed in mean number of groups of pellets among the 3 types of floodplains. When a null hypothesis is not rejected, it is useful to examine the power of a test. The power of a test demonstrates the likelihood that analysis of variance will detect true differences among means (Zar 1984: 174). The power of test in this study was 0.66 at $\alpha = 0.05$; indicating a 34% chance that we failed to reject a false null hypothesis (type 2 error) when the means were different. Therefore, we suggest that, even though we found no differences in pellet group counts between the three types of floodplains, a similar study with a greater number of replications should be conducted.

Using our calculated standard deviation as an estimate of the true standard deviation, we calculated the sample size needed to detect the difference we observed

Table 3. Means (\pm SD) of habitat variables for each of three floodplain types at the Oakmulgee Ranger District, Talladega National Forest, May 1991; $n=125$.

Floodplain type	Percent closure of tree canopy	Percent closure of shrub crown	Percent closure of herbaceous canopy	Basal area (m^2/ha)	
Headwater	97.2 \pm 7.7 A ^a	84.5 \pm 15.8 A	41.7 \pm 27.4 A	20.4 \pm 7.0 A	
Lower	99.1 \pm 1.8 A	80.3 \pm 17.5 A	37.4 \pm 26.5 A	25.5 \pm 7.4 A	
Impacted	16.4 \pm 29.1 B	34.2 \pm 28.7 B	87.3 \pm 17.8 B	2.9 \pm 4.6 B	

^aMeans separated by Tukey's studentized range test; those with the same letter within a column are not significantly different ($P > 0.05$).

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between the means of counts of groups of pellets in lower and beaver-impacted floodplains (Sokal and Rohlf 1981:263). A test at the 95% confidence level with 14 replicates of each of the three floodplain types should have a 90% probability of detecting the difference observed if it is real. This information provides guidance for designing future studies.

Heuer and Perry (1976) noted that groups of pellets were seldom found on the ground. Data from our study suggest otherwise; 60% of all pellet groups on all transects were on the ground. Whitaker and Abrell (1986) reported that swamp rabbits seldom defecated on unrotted logs, piles of logs, or logs with moss growing on them. In our study, loblolly pines with relatively rough bark that had recently fallen often had groups of pellets on them. Other, more smoothly barked (hardwood) trees that recently had fallen often had beside them groups of pellets that had probably rolled off, as suggested by Heuer and Perry (1976). We also found groups of pellets on piles of logs and on logs covered with moss.

Terrel (1972) suggested that the percentage of logs having groups of pellets, not numbers of pellets, be used as a censusing method. Such a census method probably would be skewed based on the number of logs in an area. Apparently groups of pellets on the ground were not taken into consideration by Terrel (1972).

Whitaker and Abrell (1986) proposed that pellets are deposited on logs because rabbits use them as observation posts and, thus, happen to defecate on them. They also suggested that occurrence of groups of pellets on logs decreases as summer approaches and tall vegetation obscures the view from the log, negating its value as an observation post. This proposal is a reasonable explanation of why there was a decrease in groups of pellets over time in our study and in Terrel's (1972) observations. It also is an explanation of why groups of pellets occur on logs. However, it does not support the assumption that swamp rabbits deposit pellets on logs exclusively or even most of the time, because the amount of time spent on logs will vary. Results of our study suggest that swamp rabbits probably defecate anywhere that they happen to stop; groups of pellets on elevated sites usually are more visible than pellet groups on the ground that may be partially or completely obscured by vegetation.

Korte (1975) suggested that distribution of trees and saplings and density of overstory canopies affect quality of habitats used by swamp rabbits by influencing abundance and distribution of understory vegetation. Canopy openings increase ground insolation, thus encouraging growth of herbs and shrubs. Such canopy openings may be the result of single downed trees, selected timber-management activities, or activity by beaver. Activity by beaver enhances vegetative and structural diversity resulting in greater potential for use by swamp rabbits (Allen 1985). Our beaver-impacted study areas had significantly greater percent closure of herbaceous

canopy and significantly lower values for percent closure of tree canopy, basal area of trees, and percent closure of shrub crown as compared with our nonimpacted study areas.

Korte (1975) suggested that swamp rabbits require ≥ 100 ha of swamp habitat to maintain an effective breeding population if the population is to be harvested. Care should be taken in applying this statement. Korte's work was conducted in southeastern Missouri where vast bottomlands formerly existed. Remaining bottomland forests now represent small isolated fragments of the original habitat. Based in part on Korte's work, Allen (1985) concluded that the value of wetlands as habitat for swamp rabbit is directly related to the size of the evaluation area. He also noted that "...the habitat potential of small wetlands (e.g., < 100 ha) may be minimal if surrounding land use eliminates upland cover required by the species during displacement by flooding."

Our findings indicate that in areas such as Alabama, where topographic relief results in long narrow fingers of habitat, swamp rabbits utilize even those areas in narrow headwater floodplains. However, swamp rabbits in such areas apparently do not extend their home ranges into uplands (as evidenced by our finding no groups of pellets during upland searches) but, instead, probably elongate their home ranges along the floodplain. Headwater floodplains seldom flood to the extent that swamp rabbits would be forced into peripheral habitat. Swamp rabbits occasionally are seen in uplands. However, their use of such areas apparently is minimal, and lowland areas remain the most significant headwater habitat for swamp rabbits. Swamp rabbits probably do not remain in narrow floodplains surrounded by clearcut or developed areas.

Sizes of tracts of habitat used by swamp rabbits in narrow floodplains are difficult to determine because of the linear nature of the habitat as it follows small tributaries. Narrow floodplains in Alabama are possibly important for swamp rabbits, and breeding populations probably exist in fragmented habitats. In our study, narrow drainages (< 100 m on a side) harbored swamp rabbits. However, we found groups of pellets in few drainages < 30 m on a side. If smaller floodplains are important as habitat for swamp rabbits, failure to consider them when using the habitat-suitability index model could result in undocumented loss of significant blocks of habitat. All of the floodplains in this study were creek floodplains and commonly would be considered small as compared with river floodplains. Swamp rabbits occupied these areas to some extent, as evidenced by presence of pellet groups.

Hunting pressure in these areas probably is light because smaller numbers of swamp rabbits probably would not attract many hunters. As a result, small floodplains in Alabama could support reservoir populations of swamp rabbits. Activity of beavers in narrow floodplains probably would further enhance these areas as suitable habitat for swamp rabbits.

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MANAGEMENT IMPLICATIONS

Habitat loss has been the major reason for the decline of the swamp rabbit throughout much of its range. The swamp rabbit in Alabama apparently is doing well. However, small floodplains should not be overlooked as important habitat for swamp rabbits. Results of our study suggest that narrow upstream floodplains in Alabama hold swamp rabbits. This is in contrast to the situation in Missouri, where fragments of the former extensive bottomland forests must be larger to support viable populations of the species.

More research is needed on populations of swamp rabbits. If narrow floodplains are disregarded as habitat of swamp rabbits in Alabama, a significant portion can be lost inadvertently through conversion to other land uses. Potential effects of adjacent upland harvest that might affect the ecology of remaining bottomlands should be considered. Beaver-impacted areas, with open canopies and abundant growth of herbs and shrubs, also are important for swamp rabbits and warrant more research as well.

Use of counts of pellet groups as an index of populations of swamp rabbits should include consideration of groups of pellets on the ground as well as on elevated defecation sites. In any case, the number of elevated defecation sites in an area should be examined carefully as skewed counts of groups of pellets can result due to the differences in visibility of groups of pellets where the proportions of groups on the ground varies.

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LITERATURE CITED

- Allen, A. W. 1985. Habitat suitability index models: swamp rabbit. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.107). 1-20.
- Chapman, J. A., and G. A. Feldhamer. 1982. Wild mammals of North America. The Johns Hopkins University Press, Baltimore, Maryland. 1147pp.
- Fredrickson, L. H. 1978. Lowland hardwood wetlands: current status and habitat values for wildlife. Pages 296-306, in P. E. Green, J. R. Clark, and J. E. Clark, eds. Wetland functions and values: the state of our understanding. American Water Resources Association, Minneapolis, Minnesota.
- Hays, R. L., C. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. U.S. Fish Wildl. Serv. FWS/OBS-81/47:1-111.
- Heuer, E. T., Jr., and H. R. Perry, Jr. 1976. Squirrel and rabbit abundances in the Atchafalaya Basin, Louisiana. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 30:552-559.
- Hunt, J. P. 1959. Breeding habits of the swamp rabbit with notes on its life history. J. Mammal. 40:82-91.
- Keys, J. 1983. Soil management report, Oakmulgee division, Talladega National Forest. U. S. Forest Service, 81 pp.
- Korte, P. A. 1975. Distribution and habitat requirements of the swamp rabbit in Missouri. M.S. thesis, Univ. Missouri, Columbia, 127 pp.
- Korte, P. A., and L. H. Fredrickson. 1977a. Loss of Missouri's lowland hardwood ecosystem. Trans. N. Am. Wildl. Nat. Resour. Conf. 42:31-41.
- Korte, P. A., and L. H. Fredrickson. 1977b. Swamp rabbit distribution in Missouri. Trans. Missouri Acad. Sci. 10-11:72-77.
- Lowe, C. E. 1958. Ecology of the swamp rabbit in Georgia. J. Mammal. 39:116-127.
- Rudis, V. A., J. F. Rosson Jr., and J. F. Kelley. 1984. Forest resources of Alabama. U.S. For. Serv. Resourc. Bull. SO-98 21 pp.

Comparative Use of Floodplains by Swamp Rabbits

- SAS Institute, Inc. 1987. SAS/STAT guide for personal computers. Version 6 ed. SAS Institute, Inc. Cary, North Carolina, 1028pp.
- Sokal, R. R., and F. J. Rohlf. 1981. Biometry: The principles and practice of statistics in biological research. 2nd Ed. W. H. Freeman & Co., New York, 859 pp.
- Steel, R. G., and J. H. Torrie. 1980. Principles and procedures of statistics: a biometrical approach. 2nd Ed. McGraw-Hill Book Company, New York, 633pp.
- Terrel, T. L. 1972. The swamp rabbit (*Sylvilagus aquaticus*) in Indiana. Am. Midl. Nat. 87:283-295.
- Toll, J. E., T. S. Baskett, and C. H. Conaway. 1960. Home range, reproduction and foods of the swamp rabbit in Missouri. Am. Midl. Nat. 63:398-412.
- U.S. Forest Service Southern Region. 1986. Land and resource management plan: National Forests in Alabama. 267 pp.
- Whitaker, J. O., Jr., and B. Abrell. 1986. The swamp rabbit, *Sylvilagus aquaticus*, in Indiana, 1984-1985. Proc. Indiana Acad. Sci. 95:563-570.
- Zar, J. H. 1984. Biostatistical Analysis. 2nd Ed. Prentice Hall, Inc., Englewood Cliffs, New Jersey, 718pp.

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